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TWENTY-FOURTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

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MEMBERS OF THE BOARD.

1892–1893.

HENRY P. WALCOTT, M.D., *Chairman*,	of Cambridge.
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Secretary.

SAMUEL W. ABBOTT, M.D.

Engineer.

F. P. STEARNS, C.E.

CONTENTS.

GENERAL REPORT.

The following report comprises the work of the State Board of Health for the year ending Sept. 30, 1892, under the provisions of the organic act establishing the Board, and other special acts relating to the inspection of food and drugs, and to the supervision of the general subjects of water supply and sewerage.

The report embraces the following topics : —

General Report of the Board.

Report to the Legislature upon Water Supply and Sewerage, embracing the Advice of the Board given under the Authority of Chapter 375 of the Acts of 1888.

Examination of Artificial Ice.

Food and Drug Inspection.

Summary of Weekly Mortality Reports of Cities and Towns.

Investigations of Recent Epidemics of Typhoid Fever in Massachusetts

Health of Cities and Towns.

The following members comprised the Board in 1892 : —

Henry P. Walcott, *Chairman.*

Joseph W. Hastings,	John M. Raymond,
Hiram F. Mills,	Morris Schaff,
Frank W. Draper,	Elijah U. Jones.

At the annual meeting in June, 1892, the following officers were chosen : —

Chairman, ...	Henry P. Walcott.
Secretary, ...	Samuel W. Abbott.

Under the provisions of chapter 263 of the Acts of 1882, and chapter 375 of the Acts of 1888, the following officers were also chosen: —

Under the Provisions of the Food and Drug Acts.

Analyst, ...	CHARLES P. WORCESTER.
Analyst, ...	CHARLES A. GOESSMANN.

Under the Provisions of the Acts to protect the Purity of Inland Waters.

Chief Engineer, ...	FREDERIC P. STEARNS.
Consulting Engineer, ...	JOSEPH P. DAVIS.
Assistant Engineer, ...	X. H GOODNOUGH.
Chemist, ...	THOMAS M. DROWN.
Biologist, ...	W. T. SEDGWICK.
Chemist in Charge of Experiment Station,	ALLEN HAZEN.
Biologist at Experiment Station, . . .	GEORGE W. FULLER.

INFECTIOUS DISEASES.

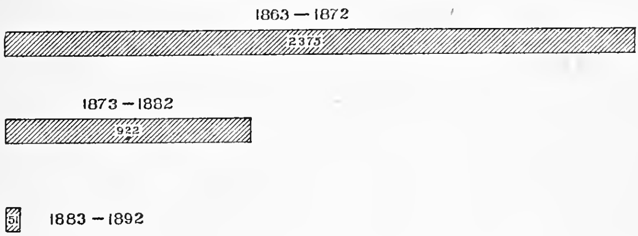
The year 1892, like the previous year, so far as concerned this Commonwealth, was not marked by any serious outbreak of epidemic disease, with the exception of the epidemics of influenza of 1891 and 1892, which began like that of 1889, near the close of the year 1891, and continued on through the months of December, January and February, and then disappeared. The course of these two epidemics is shown upon pages 746 and 747 of the last annual report of the Board (twenty-third Report, 1891). The diagrams there given do not, however, show the course of the milder epidemic which occurred in April, May and June, 1891.

Small-pox.

But few populations comprising over two million inhabitants (the German empire excepted) have been more exempt from small-pox during the decade ending with 1892 than the State of Massachusetts. The deaths from this cause in the State during the past ten years have been but fifty-one, which is a smaller number than has occurred during any consecutive ten years since 1830. The deaths from small-pox in Massachusetts for the decade ending 1882 were 922, and those for the decade ending 1872 were 2,375. While a considerable part of this unusual immunity is undoubtedly due to vaccination, we recognize that this method of prevention cannot account for all, since there is at present, as a result of neglect of local authorities, a very large unvaccinated contingent population. The towns which are most exposed to the invasion of small-pox (the paper-mill towns) are probably better protected than other parts of the State. Probably the reason for the unusual present immunity lies in the fact that this

disease has not been allowed to gain a foothold in the State, but has been suppressed in each instance upon its first appearance. There is no reason to believe, however, that this immunity will be perpetual, so long as neglect of vaccination is constantly increasing.

Deaths from SMALL-POX in Mass. by DECADES



The following summary presents the history of such cases as occurred within the State during the year, so far as they came to the knowledge of the Board: —

Record of Cases of Small-pox reported to the State Board of Health in 1892, under the Provisions of Chapter 138 of the Acts of 1883.

Number.	Place of Occurrence.	Date of Report.	Nationality.	Age, in Years.	Sex.	Deaths.	Occupation.	Previously Vaccinated.	Number of Scars.
[1]1	West Springfield,	May 4,	Scotch,	26	F.	-	House-wife,	Yes.	1
2	New Bedford,	June 6,	Portuguese,	5	-	-	-	No.	-
3	New Bedford,	6,	Portuguese,	4	-	-	-	No.	-
4	New Bedford,	6,	Portuguese,	2¼	-	1	-	No.	-
5	New Bedford,	6,	Portuguese,	1½	-	-	-	No.	-
[2]6	New Bedford,	6,	Portuguese,	22	F.	-	-	Yes.	-
7	New Bedford,	6,	Portuguese,	31	M.	-	Laborer,	No.	-
[3]8	New Bedford,	8,	Portuguese,	35	M.	-	Watchman,	Yes.	1
[2]9	New Bedford,	6,	Portuguese,	16	M.	-	Clerk,	Yes.	*
10	New Bedford,	6,	Fr. Canadian,	2½	M.	-	-	No.	-
11	New Bedford,	14,	Fr. Canadian,	5	F.	-	-	No.	-
12	New Bedford,	14,	Fr. Canadian,	3	F.	-	-	No.	-
13	New Bedford,	15,	Portuguese,	22	-	1	-	-	-
14	New Bedford,	18,	French,	17	-	-	-	-	-
[4]15	New Bedford,	18,	Fr. Canadian,	15	M.	-	Laborer,	Yes.	-
16	New Bedford,	Dec. 28,	Portuguese,	26	M.	-	Fishmonger,	No.	-
[1]17	Quincy,	June 27,	Swede,	24	F.	-	House servant,	No.	0
18	Boston,	Aug. 9,	Russian,	18	F.	-	-	Yes.[5]	3
19	Holyoke,	13,	Fr. Canadian,	17	F.	-	Rag sorter in paper mill,	Yes.	1

* None visible.

[1] Newly arrived immigrant, vaccinated five years before.
[2] Vaccinated nine years before.
[3] Vaccinated thirteen years before.
[4] Vaccinated three days before he was taken ill.
[5] Vaccinated in infancy.

The following is the account of the epidemic in New Bedford, as made by the physician of the Board of Health of that city, in his report to that Board: —

On June 3 the attention of your physician was called to suspicious illness in the middle tenement of house numbered 944 South Water Street. The investigation showed a young man, John Andrews, in the pustular stage of small-pox; two children of George Rivers, at the beginning of the stage of desquamation; a young woman, Andrews, who had had a mild case of varioloid, in the desquamation stage; and a baby of George Rivers, two years old, in the pustular stage of small-pox. Upstairs in the same house a French family lived. A man named York, with his wife and child, were visiting them. This child was in the pustular stage of small-pox.

The small-pox hospital had not been open for eleven years, but everything had been kept in readiness for cases, and the patients were all transferred to the hospital on the same day.

On the next day another suspicious case was reported at 646 South Water Street. It was found to be a case of small-pox in the beginning of the pustular stage, the patient being Charles Andrews, a brother of John Andrews. He was immediately transferred to the small-pox hospital. The other people living in both infected houses were transferred to the old poorhouse on French Avenue, where a quarantine station was established for persons who it was thought had been in any way exposed to the disease.

The cases had been going on for at least two weeks, and it was impossible to say how far the contagion had gone.

On June 8 it was reported that William Andrews, a brother of the men who were already in the hospital, was ill. On investigation, he was found to have a mild case of varioloid. He lived at the east end of Coffin Avenue. He was transferred to the hospital, and the other people in the house to the quarantine station.

On June 9 a case was reported at 305 South Second Street. It proved to be a boy with a light case of varioloid. He was quarantined at home, and another family living upstairs in the house was transferred to the quarantine station.

On June 10 one of the children of the French family named Lemaux, who had lived upstairs at 944 South Water Street, came down with small-pox at the quarantine station, and was transferred to the small-pox hospital. On June 14 the other Lemaux child also developed small-pox, and was transferred from the quarantine station to the hospital.

On June 15 Joseph Francis was found to be suffering from small-pox at 169 South Second Street. He was employed by a grocer, and had taken provisions to the Rivers family. He was at once transferred to the hospital. He was seen at the beginning of the vesicular stage. The day after he was transferred he had profuse hemorrhages from the nose, mouth, kid-

neys and bowels. There were very few pustules, but ecchymotic spots appeared on his extremities, and on the calf of the left leg there was a slough about two inches across. He died the night of June 16, and was buried the next day in the burying-ground near the hospital.

The small-pox hospital, being a small building, was crowded, and it was thought best to construct a cheap building, to be used in case other patients had to be brought to the hospital. A building was put up with eight rooms in it. It was not necessary to transfer any case to this building, but it was used for disinfecting purposes. One of the Rivers children, aged two years, had a severe confluent case of small-pox, and died from exhaustion. It was buried in the burying-ground near the hospital the next day.

On June 18 a case of small-pox was reported at 592 South First Street. This was a French boy who worked in a cotton mill, and had no apparent connection with the other cases. He was at once transferred to the hospital. He lived in a large three-story tenement house, and it was impossible to take all the inmates to the quarantine station. Only the families living on the same floor where the case occurred were transferred; the others were advised to leave the house, and they did so.

After the discovery of this case, it seemed probable that the epidemic might be extensive, and a general vaccination was advised, and ordered by the Board. This was carried out in all the factories in the city, and in the schools. A house-to-house vaccination was also ordered in the vicinity of the infected houses. The physicians were instructed to vaccinate all persons who had not been vaccinated within five years. All the tenements where cases of small-pox had been found were thoroughly fumigated and cleaned. All the furniture, carpets and clothing that had been exposed were destroyed. The tenements were washed with corrosive sublimate solution, and were entirely painted and papered.

The patients were kept in the hospital until all signs of desquamation had cleared up. Meanwhile they were washed with corrosive soap. When they were released, they were thoroughly washed with a corrosive sublimate solution, and given an entire outfit of new clothing. They were allowed to take nothing away from the hospital. After being thoroughly disinfected in this way, they were transferred to the quarantine house, and kept there several days before they were allowed to come to the city. No expense or trouble was spared to do this work thoroughly, and the result was that no new cases developed, either from the infected tenements or from the patients themselves. In the opinion of your physician, the importance of the quarantine station in this epidemic cannot be overestimated. It enabled us to vacate the infected houses at once, and not to have them occupied again until they had been thoroughly disinfected; it removed the persons living in these houses at once from a possible source of infection in the house, and it gave us the opportunity to watch the persons who had possibly been exposed to infection.

Two cases of small-pox appearing in the quarantine house showed the wisdom of this precaution. There were thirteen cases in all: one case of hemorrhagic small-pox, the patient dying before the pustular stage had developed; one case of confluent small-pox in a child two years, the patient dying of exhaustion; two severe cases of small-pox, in John and Charles Andrews; three confluent cases, in the two Lemaux children and the York child (all these three children were very ill, but recovered); three cases were mild small-pox, the two Rivers children and the French boy; and three cases of varioloid.

Within the past decade, in addition to the measures usually taken by local authorities for the prevention of the spread of infectious diseases, steps were taken at Toronto in October, 1886, toward a general reciprocal plan of interstate notification of diseases dangerous to the public health; and under the provisions of the resolutions adopted at that time by the International Conference of State Boards of Health, notices of forty-five attacks of small-pox have been received at the office of the State Board of Health, the number of specified cases being one hundred and twenty-six, with nine outbreaks in which the number was not stated. The existence of this system of notification has undoubtedly had a beneficial influence in stimulating boards of health to greater vigilance in providing the proper measures for the protection of the communities under their charge.

The sources of contagion in specified cases were from immigration from European ports, and in nine cases from neighboring States. In one instance detailed by the Board of Health of Iowa the disease was introduced from New Mexico, by parties travelling by railway, while just convalescing from small-pox, the eruption still existing in its advanced stage.

In addition to notices of small-pox, the Board also received notices of the occurrence of yellow fever, typhus fever and leprosy.

The summary of cases is as follows: —

Small-pox.

West Virginia. — January 11, one case.

New Hampshire. — January 23, one case.

Province of Quebec. — January 29, report of continuance of epidemic of December, 1891; November 10, one case.

Rhode Island. — February 4, one case; March 7, one case; July 20, three immigrants.

Pennsylvania. — March 21, one case (immigrant); March 30, one; April 1, two cases; April 19, one; May 11, two; June 15, five; July 6, eight; July 12, two immigrants; July 29, one; October 8, thirteen.

Ohio. — March 23, one; June 2 and 6, twenty-seven cases; December 30, three; December 31, one.

Iowa. — April 16, two; June 15, five.

New York. — April 23, one case; May 4, one; June 29, two; November 2, one.

Maine. — May 7, one immigrant; December 15, one; December 22, one.

Michigan. — April 25, one; May 30, one immigrant.

California. — April 29, one; May 4, one.

Illinois. — May 5, one; May 25, one.

Province of Ontario. — July 25, one; October 4, three; October 17, two; October 31, three.

North Dakota. — July 30, numerous cases.

Connecticut. — August 3, one; November 14, two; November 19, seventeen.

Minnesota. — November 14, one.

Typhus Fever.

Rhode Island. — February 13, one case.

Connecticut. — February 18, one case.

New York. — February 18, three cases.

Pennsylvania. — February 24, three cases.

All of these cases of typhus fever, together with those which are detailed on pages xvii and xviii, were contracted on board the steamer "Massilia," which arrived at the port of New York from Mediterranean ports in January, 1892.

In addition to these cases, two more were reported from Pennsylvania March 15, in the persons of two nurses who had taken care of the infected family at Oakdale, Mass.

Leprosy.

Pennsylvania. — March 5, one case, a Japanese; October 18, one case, origin unknown.

Yellow Fever.

Mexico. — September 18, numerous cases.

During the year another form of notification was also introduced by the United States Commissioner of Immigration at the port of

New York, who began in May, 1892, a system of notification of all vessels arriving at that port carrying passengers infected with contagious diseases, the object being to give to the different health authorities throughout the country notice of such persons destined to the different municipalities within their jurisdiction as had been exposed to contagion on the passage or at the time of arrival, or who had come from infected ports in other countries. By this means the local health authorities could be advised of danger, and keep such persons in surveillance when found until danger had passed. The items specified in these reports consisted of the names of the persons who had been thus exposed, their destination, the port from which they sailed, the name of the ship, and the character of the disease to which they had been exposed. On receiving these notices, the State Board of Health transcribes the particulars and sends to the Board of Health of each city and town to which such persons are destined a list of the names of these immigrants.

The following is a summary of the data given in such of these notices as were received by the State Board of Health of Massachusetts in 1892, from May 1 to November 24. Each of the following steamers brought persons suffering with small-pox to the port of New York: the "Anglia," "Westernland," "Belgenland," "Aurania" (twice), "Schiedam," "Saale" (thrice), "P. Calland," "Waesland," "Werkendam," "City of Chester" and "Teutonic." The "Rugia" brought cases of typhus fever (July 24). The "Sorrento," "Moravia," "Normannia," "Rugia," "Scandia" and "Bohemia" came from ports infected with cholera.

The number of immigrants destined for Massachusetts who came upon these vessels was three hundred and thirty-three, all of whom were distributed through the State in its cities and large towns, chiefly in manufacturing districts. It is worthy of note that scarcely any cases of infection followed the coming of these immigrants, and the few cases which did occur were with one or two exceptions confined to the persons of the immigrants themselves.

Typhoid Fever.

The decrease in mortality from this disease from year to year throughout the State has been very marked, and has kept pace with the introduction of pure domestic water supplies in the cities and towns. The relation of the prevalence of this disease to the pollu-

tion of public water supplies has been shown in recent reports of the Board (twenty-second annual report, p. 525).

The following mortality rates show the decrease in mortality from typhoid fever per 10,000 of the population in census years: —

Death Rates per 10,000 from Typhoid Fever in Census Years, 1865-90, by Counties.

COUNTIES.	1865.	1870.	1875.	1880.	1885.	1890.	Average.
THE STATE,	13.4	9.1	6.4	4.9	3.9	3.7	5.0
Barnstable,	16.7	12.8	5.6	4.1	2.7	4.5	8.0
Berkshire,	23.3	8.2	7.6	5.6	3.3	4.3	8.1
Bristol,	14.5	7.9	5.4	5.4	3.8	3.0	5.9
Dukes and Nantucket,*	17.8	22.7	12.4	3.7	6.9	-	10.8
Essex,	12.9	9.4	5.1	5.6	3.8	4.6	6.5
Franklin,	25.2	11.6	8.9	4.9	3.7	2.6	9.0
Hampden,	16.1	15.4	9.7	7.2	5.1	4.8	8.8
Hampshire,	18.3	10.3	10.9	5.5	4.9	2.9	8.5
Middlesex,	8.9	6.5	5.1	4.0	3.5	4.9	5.3
Norfolk,	8.9	5.9	5.9	3.4	4.4	2.2	5.1
Plymouth,	20.2	7.8	6.0	5.1	2.9	2.6	6.8
Suffolk,	7.7	7.6	6.6	4.1	3.7	3.2	5.1
Worcester,	17.7	12.1	6.6	6.0	4.2	2.9	7.5
* Dukes,				2.3	9.7	*	-
* Nantucket,				5.4	3.2	*	-

* No deaths from Typhoid Fever.

During the past year several localized epidemics in the State have presented conditions that were unusually favorable for a careful study of this disease in its relation to water supplies, milk supplies and other etiological factors. The Board has intrusted the investigation of these local epidemics to Prof. W. T. Sedgwick, whose papers upon the subject form a portion of this report.

Typhus Fever.

So rare is the occurrence of this disease in the United States in recent years that very few members of the medical profession ever have an opportunity to become familiar with it. It is invariably imported from foreign cities, and usually its appearance is limited to the large seaports. In an epidemic in New York in 1881 and 1882 there were seven hundred and thirty-five cases admitted to the

Riverside Hospital. Every outbreak in recent years in the United States has been traced to foreign immigration.

The following description, by Dr. J. B. Russell of Glasgow, presents its natural history and causes in a graphic manner: —

As far into the past as authentic history permits us to penetrate, we find that it follows popular misfortune like a dark shadow. It dogs the footsteps of war, aggravates the miseries of famine, and haunts prisons and workhouses whenever authority forgets that criminals and paupers do not cease to be human beings. Typhus has during this century devastated all parts of Europe, and been active, though much more rarely, in Asia, in Africa and South America. . . . The habitat of typhus for English-speaking people is Ireland. It never dies out in Ireland. Thence it established itself in England and Scotland, beginning always in western seaports, where intercourse with Ireland is most direct. It followed the stream of Irish emigration to North America and Canada. The course of the vessels in the earlier days of the exodus, before government regulated the traffic by inspection of passengers and enforcement of marine sanitation, was marked by the corpses of those who died of this disease on the voyage. Every epidemic explosion in Ireland has been immediately followed by its echo along our shores, and on the American continent.

In further describing its appearance in Glasgow, he says: —

The houses of the Irish and the Scotch-Irish, and of those who have learned their habits, keep up the pedigree of typhus without interruption even for a single month. It is only at the cost of the maintenance of daily supervision and the enforcement of hospital isolation that we prevent epidemics. Every dirty, overcrowded house is a potential epidemic centre. In spite of every precaution, families of cleanly citizens every now and then fall innocent victims to the license of their uncleanly neighbors. Only let the restrictive measures be suspended, and this disease, which is maintained in domestic filth and overcrowding, would involve the whole community without discrimination.

Hirsch further describes its causes as follows: —

It is always and everywhere the wretched conditions of living which spring from poverty and are fostered by ignorance, laziness and helplessness, in which typhus takes root and finds nourishment; and it is above all in the *want of cleanliness, and in the overcrowding of dwellings that are ventilated badly, or not at all, and are tainted with corrupt effluvia of every kind.*

The diagnosis of typhus in its early stages is not an easy task, especially for physicians who are entirely unfamiliar with its appearance. It is therefore a matter of congratulation that the character of the different outbreaks which occurred in Massachusetts in 1892 should have been recognized early, and the patients promptly isolated. To the promptness of the local authorities in this matter is undoubtedly due the limitation of these outbreaks to the initial families and cases which occurred in each instance.

About the middle of February, 1892, the Board received notice of the occurrence of cases of illness in a family in the village of Oakdale, West Boylston, which, from their history and the character of the symptoms, were believed to be cases of typhus fever. As soon as the character of these cases had been determined by the local Board of Health of West Boylston, the family, consisting of father, mother and five children, all of whom were taken ill except the father, were removed from the tenement-house in which they had taken their abode, and quarantined in a house upon a hill quite remote from the inhabited portion of the village, and well suited to the purpose of isolation. Nurses had been sent to this family by a Jewish organization in New York, and after they had returned to their homes it was reported that they were attacked with the same disease, probably contracted from the family at Oakdale.

The secretary went to Oakdale February 16, and found that satisfactory measures had been taken by the local authorities for the prevention of the spread of the disease.

During the same week report was received from North Oxford that a woman was ill with the same disease in that town. This woman with her husband had arrived in North Oxford about the same time with the arrival of the preceding cases at Oakdale. The two towns are about twenty miles apart, and on opposite sides of the city of Worcester. The Oxford family lived in a tenement in a house near one of the mills, in which they were employed. Isolation was enforced, and no further cases occurred here.

Soon after the occurrence of these cases report was received of the existence of other cases at Middlefield, a small town near the Westfield River. These cases, four in number, were employees in a hosiery mill, who had recently come to that town. The party consisted of sixteen Russians. The victims of fever were a young man of twenty and his sisters, aged nineteen and eight. Another patient, a young man, also belonged to a Russian family.

What was the history of these cases? Each and all of these persons attacked with typhus fever were passengers on board the steamer "Massilia," which arrived at the port of New York Jan. 30, 1892. They came from southern Russia, embarking at Marseilles Jan. 1, 1892. Thence they went to Naples, where many Italians were also received. They left Naples January 7. The steamer was one of the Fabre line, plying between New York and Marseilles and Naples. It was not a large steamer, but according to published statements contained 1,538 Russians, in addition to the Italians taken on board at Naples. On arriving at New York these passengers were distributed throughout many of the northern cities and towns of the United States; two hundred or more remained in New York City.

Within two weeks a considerable number of these immigrants in New York City were taken ill with typhus fever, and within a day or two later other cases were reported from Philadelphia, Pittsburg, Chicago, Trenton, Providence, and from the small manufacturing towns in Massachusetts already named, these first cases invariably being immigrants who had arrived in the "Massilia" at New York January 30. By February 25 the cases in New York had increased to one hundred and seven, of whom ninety-nine were known to be the "Massilia's" passengers. On March 9, one hundred and fifty-three persons had been attacked with the disease in New York, and thirteen of these had died; and on March 18 the deaths were twenty-six and cases one hundred and fifty-five. A few other persons who had been directly exposed were taken ill, but by the middle of March this outbreak was practically under control and ceased to spread.

All of the immigrants who came to Massachusetts and were attacked with typhus fever recovered; the six cases at Oakdale were the most severe.

Diphtheria and Scarlet-fever.

Diphtheria prevailed in many cities and towns in 1892, with about the same degree of severity as was manifest in the preceding year, and scarlet-fever with still greater frequency; but the type of the latter disease has in the past two or three years been much less fatal than it was in previous years. The Board was called upon several times to investigate local outbreaks of these diseases at Palmer, Worcester, Egremont, Holbrook, Marlborough, East Douglas and other places. The conditions which prevailed at these places presented but little variation from those which have been noted at other places, and have been published in earlier reports of the

Board, except in the case of Worcester, where the greater portion of the cases of diphtheria were confined to a limited district of the city in the neighborhood of a public school.

Early in the winter of 1891–92 cases of diphtheria occurred in the immediate neighborhood of the Dix Street school-house. Three cases were reported in this neighborhood between May 20 and the closing of the school for the summer. In August and September there were nine more cases in the same district. Four more cases occurred at intervals of three or four weeks, and after the beginning of the year (1892) their occurrence was more frequent; and the fact that many of those attacked were pupils in the Dix Street school led the authorities to regard the school as a possible centre of infection. The local Board of Health, finding that no *special* authority is granted to them by law to close a school-house as a public health measure, recommended the school board to close the school, and to have the building disinfected and certain changes made in its means of drainage and ventilation. The State Board of Health was requested to visit the school, and to offer any suggestions which might be demanded for the improvement of its condition. After visiting the school the secretary addressed the following communication to the Board of Health of Worcester: —

Commonwealth of Massachusetts,
State Board of Health, 13 Beacon Street,
Boston, Jan. 30, 1892.

To the Board of Health, Worcester, Mass.

Gentlemen: — In compliance with your request, I visited the Dix Street school-house in Worcester yesterday, and after considering the matter have thought it proper to address the following suggestions to you. As you may understand, the State Board of Health has no executive authority over school buildings; I therefore write to you from my own view of the case.

In the first place, the school-house is located in a district which has recently suffered more from diphtheria than other parts of the city. Whether the school-house has itself become a centre of infection, it is impossible to say, but the occurrence of a considerable number of cases of diphtheria among the members of the school would warrant such probability, at least. The continued prevalence of cases among the school children might be caused either by exposure to other cases, or to infection remaining in the school-rooms, derived from unrecognized cases. With this uncertainty in view, I think it would be advisable to disinfect the school-house as thoroughly as possible, by the use of sulphur, by washing

floors and walls and lime-washing the latter and ceilings. I should think it well to use a sublimate solution upon the floors. After the disinfection the windows and doors should be opened and left open all day, for at least two or three days, especially in windy weather, and I should attach as much value to this process as to the disinfection. I do not think the length of time after disinfection elapsing to the re-opening of school is a matter of much importance, provided the disinfection and airing is well done. With regard to the system of ventilation in use at this building I have little to say, as I am not sufficiently familiar with its operation. The few minor faults which are apparent can be remedied, especially the lack of suitable means for removing the liquid filth from the bottom of the shaft at the end of the system of closets upon the girls' side of the basement.

Yours respectfully,

S. W. Abbott, *Secretary.*

Since this case presents certain points which may be useful to the authorities of other cities and towns, the following action and statement of the local Board is published herewith: —

In order that there should be no delay in the closing of a school building, should occasion arise in the future, the school committee, at a regular meeting, held February 2, granted the necessary authority to the superintendent of schools, on recommendation of this Board, as will appear from the following copy of a communication received from the superintendent of schools: —

Office of Superintendent of Schools, 492 Main Street,
Worcester, Mass., Feb. 5, 1892.

To the Board of Health.

Gentlemen: — At a meeting of the school board on the 2d inst. the following was adopted and ordered sent to your honorable body.

Very respectfully yours,

A. P. Marble, *Secretary.*

Resolved, That this committee does hereby respectfully request the Board of Health to report to the superintendent of schools, without delay, all cases of scarlet-fever or diphtheria hereafter coming to their knowledge and traceable to any public school-house in this city; stating whether or not, in their opinion, the occupancy of such house for school purposes would be detrimental to the health of the scholars.

Resolved, That said superintendent be, and he hereby is, authorized and directed, upon receiving a written report from the Board of Health indicating the unhealthy condition of any school-house in this city, to discontinue the schools in such house for a term of fourteen days, or such time as the Board may think necessary, and forthwith request the superintendent of public buildings to fumigate and cleanse said house, and prepare the same for safe occupancy at the close of said term.

From May 20, 1891, to March 1, 1892, there were forty-four cases of diphtheria and sixteen deaths. Since that time up to Jan. 1, 1893, there have been six cases in this district, only two of which attended the Dix Street school.

Diphtheria is not always the terrible malignant disease which we associate with the name; it may be very mild, so mild, indeed, that the patient attends to his business, or, if a child, goes to school. Free from danger to himself, he is capable of bringing to those with whom he comes in contact severe illness and death. What is considered an ordinary sore throat or a non-contagious tonsillitis may be and very often is diphtheria; if it be, the havoc it may work is incalculable.

The practical point of the whole matter is this: while not neglecting any precaution which will conduce to make our houses healthy, while being vigilant to secure good ventilation, drainage, water supply and cleanliness, as being all of them necessary to good health, let us look for the cause of diphtheria where it may be found, in the throats of individuals who have the disease, no matter in how mild a degree. It was one of these supposed "sore throats," later recognized as malignant diphtheria, and resulting fatally in a few days, that carried infection into the Dix Street school, and made it a centre of contagion. Every sore throat should be regarded as suspicious, — it may be diphtheria; such cases should be isolated if there be other children in the family. A child with sore throat should not be sent to school, nor neighbors' children invited to play with him.

In conclusion, diphtheria is a specific. contagious disease. It may be mild or severe. The poison exists in a germ, which is never spontaneously generated; it is usually received by direct contact with an individual who has diphtheria; but it may be derived from articles which have come in contact with him, as furniture, clothing, books, etc., and even pets, as dogs and cats. Safety lies in isolation of all suspicious cases.

Cholera.

In anticipation of the possible invasion of cholera during the summer of 1892, active preparations were made throughout the State by local boards of health for dealing with the disease, if any cases should occur within the limits of their respective authorities. An unusual amount of sanitary house-to-house inspection was performed, and very many nuisances were abated. Local cleansing and disinfection were conducted on a more extensive scale than ever before.

The State Board of Health prepared and issued an edition of the following circular, which was sent throughout the State to local boards of health and to all persons and authorities to whom such a circular might be useful: —

PRACTICAL SUGGESTIONS RELATIVE TO CHOLERA.

[A circular from the State Board of Health of Massachusetts.]

In view of the appearance of epidemic cholera during the present year in foreign ports and cities, and of the possibility of its occurrence in the cities and towns of Massachusetts, the following circular is issued by the State Board of Health for the guidance of local boards of health and all others whom it may concern.

While recognizing the extremely infectious nature of cholera, the Board emphasizes the fact that the presence of imported cases ought not to prove a source of alarm to a community if the place receiving the infection has had, and *continues to have*, thorough sanitary care and supervision.

The discharges from the bowels are without doubt the chief source of infection. Vomited matter is open to suspicion, and should be similarly treated. In proportion as carelessness and neglect are permitted in the disposal of these discharges, the disease is liable to spread. Under ordinary circumstances, it is probable that a patient suffering with cholera has no power to infect others except by means of such excreta. Nor is it probable that he has any power of infecting at all, except in so far as particles from these discharges may infect the food, water or air which others consume.

A healthy person coming from an infected district may carry the infection of cholera upon the hands, or other parts of the body, or upon the clothing; and such person should be under the surveillance of the local board of health, and should not be allowed to mingle with the community, and especially should not engage in any occupation by which dust from the clothing, or infection from the person, may enter the food or drink of others, until the board is satisfied that he and his clothes are no longer reasonably open to suspicion as vehicles of disease.

Strong soapsuds may be used for bathing the body. (For the treatment of clothing, see instructions relative to *Disinfection.*)

A person arriving in a city or town, who is sick, his illness being known or suspected to be cholera, should not be allowed to dwell in a crowded community, but should be taken to a house having an open space around it, and immediately placed under the charge of a physician. He should be kept warm until the physician arrives. If there should be any doubt as to the character of the illness, the State Board of Health will, upon application, send an expert to decide the question.

The room occupied by the patient should have no carpet, and all articles not immediately needed, including extra clothing and tapestry, that may retain dust, should be removed. Dust upon the floor and furniture should be removed daily by wet cloths wrung out of strong, hot soapsuds, or solution of carbolic acid, and then burned. It would be well to have all the furnishings of the rooms devoted to the care of the sick of so cheap a character that they may finally be burned.

The utmost cleanliness should be practised by the attendant both in regard to his own person and clothing and to the person of the patient, and to all articles in the sick-room; and the attendant should not prepare food for himself, his patient or others, whereby it would be possible for infection to enter it from his person or his clothing. The hair of the attendant should be closely covered, to exclude dust. The dishes and utensils used in the sick-room for food or medicine should not be taken to the kitchen, but should be washed with boiling water, and should be kept separately for this use and not be used by any other person. No food should ever be returned from the sick-room or from the attendant's room to the kitchen.

Special care should be taken in the disposal of the discharges of the sick. They should be treated with an equal volume of the milk of lime. They should not be carried through the house uncovered, and all vessels and their covers and the hands of the persons carrying them should be thoroughly washed with solution of carbolic acid. The discharges should be prevented from penetrating the mattress by a covering of rubber cloth.

The clothing of the attendant and of the patient, and other fabrics used in the sick-room, should be frequently cleansed by boiling. If it becomes necessary to take such clothing to the kitchen or cook-room for the purpose of boiling, they should first be soaked in a saturated solution of carbolic acid for twelve hours.

The attendants should not go into other rooms than those intended for their exclusive use without bathing and change of clothes. Should it be necessary for other persons besides the attendants to enter the sick-room, they should take the same precautions not to carry infection from it upon their persons or their clothes.

The local board of health should provide a hospital where all cases which cannot be properly isolated at home should be cared for. The hospital should be provided with a furnace or crematory, removed from other buildings, where the excreta from patients, and old clothing, may be burned, and a room should also be provided where bedding and clothing from the hospital and from other places can be exposed to prolonged heat at a temperature of at least 212° F. (100° C.).

In addition to the other precautions which have been mentioned, the following considerations relative to the modes of propagation of cholera should be borne in mind: —

a. By leakage from privy vaults and cesspools, and also by surface drainage, the infective material of the cholera discharges may gain access to wells or public water supplies, and thus impart to great volumes of water the power of propagating the disease.

b. The careless disposal of choleraic discharges, by suffering them to pass into public or private water-closets, sewers or cesspools without disinfection, infects the sewage therein contained, and possibly the effluvia

evolved by such sewage. The effluvia from privies or even from improperly cleansed vessels which had once contained such discharges may likewise be infectious.

c. The infective power of cholera discharges attaches to bedding, clothing, towels and other articles which have been soiled with them, and renders them as likely to spread the disease in distant places to which they are sent as in like circumstances the patient himself would be. The infective material of cholera is not discernible by the unaided sense of sight or by smell, and may become attached to clothing, linen, bedding or other articles without being detected by ordinary means. Hence all such articles should be thoroughly disinfected by prolonged boiling or by soaking in the saturated solution of carbolic acid for twelve hours before being removed from the rooms devoted to the care of the sick.

It is also recommended that immediate and thorough examination of the public water supplies should be made by local boards of health, especially when such supplies are liable to the least suspicion of contamination. If pollution is discovered, immediate measures should be taken for preventing its continuance.

The surroundings of private wells should also be examined with reference to possible sources of infection. Careful attention should be given to the removal of house refuse, offal and garbage, and accumulations of filth in neglected places.

Local boards of health are urged to make thorough inspection of the water supply and drainage of all public institutions, school-houses, railroad depots, picnic and camp grounds, travelling shows and all places where people are accustomed to assemble.

The following existing statutes relative to dangerous infectious diseases should be carefully complied with : —

[Acts of 1890, Chapter 102.]

When a householder knows that a person within his family or house is sick of small-pox, diphtheria, scarlet-fever *or any other infectious or contagious disease dangerous to the public health,* he shall immediately give notice thereof to the board of health of the city or town in which he dwells, and upon the death, recovery or removal of such person, such of the rooms of said house and such of the articles therein as, in the opinion of the board of health, have been subjected to infection or contagion shall be disinfected by such householder to the satisfaction of said board of health. Any person neglecting or refusing to comply with either of the above provisions shall be punished by a fine not exceeding one hundred dollars.

[Acts of 1884, Chapter 98.]

Sect. 2. When a physician knows that a person whom he is called to visit is infected with small-pox, diphtheria, scarlet-fever or *any other disease dangerous to the public health,* he shall immediately give notice thereof in writing over his own signature to the selectmen or board of health of the town; and if he refuses

or neglects to give such notice, he shall forfeit for each offence not less than fifty nor more than two hundred dollars.

Sect. 3. The boards of health in the several cities and towns shall cause a record to be kept of all reports received in pursuance of the preceding sections, and such record shall contain the names of all persons who are sick, the localities in which they live, the diseases with which they are affected, together with the date and the names of the persons reporting any such cases. The boards of health shall give the school committee immediate information of all cases of contagious diseases reported to them according to the provisions of this act.

Sect. 4. The secretary of the Commonwealth shall furnish the boards of health with blank books for the record of cases of contagious diseases as above provided.

Individual Precautions.

The following precautions are recommended to private individuals, and especially to householders: —

1. *Domestic water supply.* The supply of water for household purposes should be pure, and especially free from contamination by house drainage. Wells located in close proximity to privies and cesspools are always open to suspicion of contamination. If there is any question as to the quality of the drinking water, it should be boiled a half-hour before using.

2. Good, wholesome food should be eaten, such as people have found it best for them to eat at other times.

Fruit should be ripe and sound, and vegetables should be fresh and properly cooked. Excesses in eating and drinking and indigestible food should be avoided.

Care should be taken to secure a milk supply which is above suspicion. In case of an epidemic, all milk should be boiled.

3. Every householder should carefully attend to the condition of the water-closets, privies, cesspools, drains, cellars, stables, yards, outbuildings and sheds upon his premises, and cause them to be kept in a cleanly condition.

Disinfection.

The following disinfectants are recommended: —

1. *Milk of lime.* Milk of lime may be prepared by sprinkling one quart of water gradually upon a quart of quick-lime in broken pieces in a metallic or wooden vessel. When the lime is reduced to powder, three quarts of water should be added, and the whole kept in a covered vessel.

2. *Chloride of lime.* (One part of lime to fifty parts of water.) The chloride of lime should be fresh, and may be used either in powder or in solution.

3. *Solution of potash soap.* (Three parts of soap to one hundred of hot water, or one pound to four gallons of water.)

4. *A saturated solution of carbolic acid.* If the crude acid is used it should be dissolved in the warm soap solution, one part of carbolic acid to

twenty of the soap solution. Pure acid may be dissolved in water without the soap (one part to twenty).

5. *A temperature of at least 212° F.* (100° C.) for an hour, either by boiling, baking or steam heat.

Mode of Employment.

For the disinfection of excreta. The excreta of cholera patients should be received into metallic or earthen vessels, and mixed at once with equal parts of milk of lime. Chloride of lime may also be used, in the proportion of two heaping tablespoonfuls to each pint of liquid excreta.

For disinfection of the hands, etc. The hands and other parts of the body which may have become exposed to infection from excreta, soiled clothing or bed linen, should be washed in a solution of chloride of lime (one part of lime to fifty parts of cold water) or a saturated solution of carbolic acid.

Bed linen, shirts and such articles as can be washed should be washed in strong soapsuds, and subjected to a boiling heat for half an hour, or they may be placed in the carbolic acid solution for twelve hours.

Clothing which cannot be washed should be subjected to heat above 212° F. Articles of leather and rubber may be treated with the carbolic acid solution.

The *exposed wooden or metallic surfaces of furniture* should be washed with cloths wet with solution of carbolic acid. The floors of sick-rooms should be treated in the same manner. The cloths thus used should be burned.

The *sick-room* should not be used by others until the walls and floor have been scrubbed with cloths wet with solution of carbolic acid and the ceiling whitewashed. The doors and windows should be kept open for at least twenty-four hours afterward, to allow a free admission of out-door air.

Concrete, asphalt, brick and other pavements and gutters exposed to cholera infection should be flooded with milk of lime.

Upholstery, feather-beds and mattresses should be subjected to steam heat in a disinfecting apparatus. Where this is impracticable, they should be destroyed by burning.

Straw and excelsior bedding, rags, old clothes and other articles of little value should be destroyed by fire.

The use of proprietary disinfectants and patent remedies for cholera should be avoided.

Suggestions to Physicians.

The Board recognizes that success in the preventive treatment of cholera depends very largely for its efficiency on the willing aid of the attending physician. His position and his special training enable him to make a proper use of the means for the management and control of the disease, and his daily intercourse with the people makes it possible for him to be

very useful in promoting the measures adopted for insuring the public health and in allaying needless panic.

The special points to which the attention of the practising physicians is directed are : —

1. Immediate notice of each case to the local board of health of the city or town in which the case occurs.

2. In doubtful cases the same precautions as to isolation and disinfection should be employed as in an undoubted case of cholera.

3. Disinfection of the discharges should be practised as recommended in the foregoing instructions.

4. The patient should be isolated, and where this is impracticable he should be taken to a hospital provided for the purpose.

5. The nurses and attendants should be carefully instructed as to the disinfection of their hands, their clothing, and the care of the food.

6. Excreta of the sick and other infected material should not be disposed of upon the cultivated soil, nor in the neighborhood of wells, springs or water supplies, but should be thoroughly disinfected or destroyed by fire.

7. In case of death of the patient the burial should take place as soon as possible and in all cases should be private.

8. Since exactness in diagnosis is essential, experts will be sent by the State Board of Health to determine the character of any case of which the Board receives notice at its office, No. 13 Beacon Street, Boston.

Office of the State Board of Health, Boston, September, 1892.

The following circular, upon the same subject, issued by the Imperial Board of Health of Germany, contains so many practical suggestions that the State Board of Health of Massachusetts deemed it worthy of translation, and distributed it throughout the State in connection with its own circular : —

Berlin, July 28, 1892.

INSTRUCTIONS WITH REGARD TO THE NATURE OF CHOLERA, AND CONDUCT TO BE OBSERVED DURING ITS PREVALENCE.

1. The infectious element of cholera is found in the discharges of the sick, and by means of these discharges may be transferred to other persons and to objects of the most varied description, thus diffusing the infection. Some of these objects are articles of clothing, especially underclothing of every description, cloths, articles of food and drink, etc. ; by all of these the disease may be conveyed from the sick to the well, even when traces of the discharges are present in quantity too small to be perceived by any of the unaided senses.

2. The spread of cholera from one locality to another may therefore easily take place, when a person actually diseased or recovering from the

disease, or a person who has been in contact with the sick, leaves his habitual residence and seeks another presumably safer. The objections to such change of residence are, that the person may have been already infected; and, if not, that he will probably fare better under his customary surroundings, pursuing a well-regulated habit of life with appropriate precautionary measures, than he would in a strange place or upon a journey.

3. To avoid the danger of introducing the disease into their homes, people should not receive those coming from infected districts. Upon the appearance of cholera in a place all persons therein are to be regarded as possible carriers of disease.

4. In a cholera epidemic all persons should live a carefully regulated life. Experience teaches that disturbances of digestion favor an attack of cholera; therefore, excesses in eating or drinking, and the use of substances difficult of digestion, should be strictly avoided. Especially are those substances to be discarded which produce diarrhœa or disturb the stomach. Should diarrhœa appear, a physician should be at once consulted.

5. No food should be eaten which comes from a house wherein a person is sick with cholera. Such articles of food or drink by means of which the disease can be easily transmitted are to be avoided; as fruit, vegetables, milk, butter, fresh cheese; or, if taken, should be first cooked. Milk appears to be especially dangerous in its uncooked state.

6. All water that can by any possibility have become polluted by excrement, urine, kitchen waste or other foul material, should be carefully avoided. Water from an inhabited watershed is suspicious, as is also water from swamps, ponds and streams or rivers, because these are likely to receive drainage from impure sources; especially dangerous is a water which can have received the discharges of the sick, no matter how remotely. In this connection especial care must be taken that water in which the garments of the sick or their cooking utensils or table service have been washed shall not obtain entrance to a water supply directly or indirectly, by being poured upon the surface of the soil in vicinity of the water. The best water is furnished by deeply driven pipe wells.

7. If it is not possible to get a water above suspicion, the water should always be boiled, and only boiled water should be drank.

8. The observations above made in respect to drinking water apply also to all water used for domestic purposes, because infectious matters existing in waters used for washing dishes and household utensils, for washing and cooking food, for washing and bathing the body, may thus be brought into the human system. In general, a warning should be given that drinking water is not the only carrier of the disease, and that full protection is not secured even when a pure drinking water, or one that has been boiled, is used.

9. Every patient with this disease may become the starting-point of an extensive epidemic, and it is therefore advisable not to retain the sick

person in a dwelling-house, but to remove him to a proper hospital whenever possible. If such removal is not practicable, prevent, as far as may be, all visiting of the sick.

10. No one, unless he be called by duty, should visit a house where cholera exists. Also in time of epidemic people ought to avoid crowds, such as fairs, public markets, theatres and the like.

11. Food or drink should not be taken in rooms where the sick are, also for personal reasons no smoking.

12. As the discharges are especially dangerous, clothing of all kinds that may be polluted thereby should be at once burned or disinfected, as thereafter directed.

13. Especial care should be taken that the discharges do not come near wells or streams used for water supply.

14. Everything that comes in contact with the sick, and which cannot be destroyed or disinfected, should be removed to a specially arranged disinfection station, to be there made harmless by means of steam; or should be disused for at least six days and set away in a dry, sunny, well-aired place.

15. All persons coming in contact with the patient, his bed or his clothing, should immediately disinfect their hands, especially when they become soiled by the discharges. Emphatic warning is to be given not to touch food with infected hands, or to place anything in the mouth which may have become infected in the sick room; *e. g.*, glasses, dishes, spoons, forks, cigars, etc.

16. When a death occurs, the corpse should be removed as soon as may be from the dwelling-house to a mortuary. If the corpse cannot be washed in the mortuary, omit the washing. The funeral should be as simple as possible, moreover, should not enter the house, and there should be nothing in the nature of a wake.

17. Clothing or other articles belonging to the sick or the deceased must not be used or given away until they have been disinfected; especially must not be sent in their infected condition to other places. Whoever receives such articles from places where cholera exists is earnestly advised to have them properly treated at a public disinfecting station, or to cause them to be disinfected under their own direction. Body clothing, sheets, etc., of cholera patients, should not be washed until disinfected.

18. No other means of protection against cholera than those above given are known, and the public are warned against the use of the regularly vaunted proprietary medicines which are supposed to prevent cholera.

Suggestions for the Management of Disinfection in Cholera.

A. — The Means to be Employed.

1. *Milk of lime.* To prepare this, take one litre (about a quart) of pure, broken quick-lime, add to three-fourths of a litre (about three-fourths

of a quart) of water in appropriate vessel; when the lime has taken up the water and become reduced to a powder, add three and one-fourth litres (about three and one-half quarts) more of water and stir the mixture well; keep in a well-closed vessel and shake before using.

2. *Chloride of lime.* This is a satisfactory disinfectant only when freshly prepared and kept in well-closed vessels. A good preparation can be recognized by the well-known odor of chlorinated lime. It may either be used in form of powder or in solution; the latter to be made by mixing two parts of chlorinated lime with one hundred parts of cold water; after the undissolved portions have settled, the clear fluid should be poured off.

3. *Solution of potash soap.* (So-named green, black, soft soap.) Three parts of soap to be dissolved in one hundred parts of hot water; *e. g.*, one-half a kilogram (about one-half a pound) soap in seventeen litres (about four and one-half gallons) of water.

4. *Solution of carbolic acid.* Crude carbolic acid dissolves imperfectly, therefore is not suitable for use. The so-named one hundred per cent. carbolic acid of commerce dissolves in the soap solution, and is a convenient form of the acid for use. Take the solution of soap described in section 3; to twenty parts of this warm solution add one part of this carbolic acid and stir in. This preparation keeps well and is a better disinfectant than the plain solution of soap. If the distilled qualities of carbolic acid are used, which, though much dearer, are no better as disinfectants than the above-named one hundred per cent. carbolic acid, the soap solution is not necessary; simple water suffices as a solvent.

5. *Steam apparatus.* Apparatus arranged for direct application of steam at 100° C., or that arranged for superheated steam, may be employed.

6. *Boiling the articles to be disinfected half an hour at least.* Boiling to be constant and articles to be well covered by the water.

B. — Manner of Use.

1. The fluid discharges, vomit or excrement, to be mixed in vessels with equal quantities of the milk of lime (A 1). Mixture to stand at least one hour before it is put to one side as innocuous. Chloride of lime may also be used, two heaping tablespoonfuls in powder form to be added to each half litre (pint) of discharges, and to be well mixed. Disinfection will be accomplished in fifteen minutes.

2. Whenever the hands and other parts of the body come into contact with infected objects, discharges of the sick, soiled clothing, etc., they must be at once disinfected by thorough washing with the chloride of lime solution or with the carbolic acid solution.

3. Bed and body linen, as well as other clothing of washable sort, are to be placed in receptacles filled with a disinfecting fluid as soon as infected. The solution for this purpose should be either the soap preparation or the carbolic acid mixture. In the first named these articles should remain

twenty-four hours, in the last twelve hours, before final washing. These articles can also be disinfected in steam apparatus and by boiling with water; but even in this treatment the objects must first be well moistened with one of the above-described disinfecting fluids, and inclosed in well-secured receptacles or in bags, or wrapped up in cloths also wet with disinfecting fluid, in order that employees, who have the handling of these objects before the disinfecting process is completed, may not be unnecessarily exposed. In every case all who touch such articles should at once disinfect their hands, as above directed.

4. Garments not washable are to be disinfected in steam apparatus. Leather articles to be rubbed with carbolic acid solution or chloride of lime solution.

5. Wooden and metallic surfaces of furniture, etc , and other similar objects, to be rubbed repeatedly with rags moistened in carbolic acid solution or soft soap solution. Floors of sick-room to be treated in same way. The rags after use to be burned. The floor can also be treated with milk of lime, which should remain in contact with it at least two hours, and may then be wiped off.

6. The walls of the room and such woodwork as will not be injured by the treatment can be whitewashed. After disinfection of a room has been accomplished it should be left vacant for at least twenty-four hours, and well aired.

7. Soil, pavement or gutters, fouled by cholera discharges, may be disinfected by copious flooding with milk of lime.

8. In privies a litre of milk of lime should be poured daily down each opening. Any receptacles used in the privy vault to receive excrement should, after emptying the same, be well covered with milk of lime, inside and outside. Wooden seats in privies should be washed with the soft soap solution.

9. In case a sufficient disinfection, as above directed, cannot be obtained, *e. g.*, in the case of stuffed furniture, feather beds, etc., and a steam disinfection apparatus is not accessible, or if disinfecting solutions are not at hand, then the articles needing disinfection are to be put out of use for at least six days, in a place protected from rain but as much as possible exposed to sun and air, where there can be no access to them.

10. Objects of little value should be destroyed by burning.

Advice to Physicians as to Co-operation in Sanitary Measures to be carried out in Time of Prevalence of Cholera.

The success of any measures inaugurated by public sanitary authority depends in no small degree upon the assistance given by physicians in their execution. Their special knowledge enables them to appreciate the significance of measures recommended, and their relations to the public give them abundant opportunity to exert their great influence in the interest of the

public weal. The members of this profession have so often and in so high a degree, in like circumstances, shown their devotion to the public good, that it is not permitted to doubt that here also in the struggle with cholera, both in general and in each individual case, their willing co-operation will be given.

The points at which this activity can be most usefully shown are stated in the following sections : —

1. Every suspicious case to be immediately announced to the district medical officer and to the local police authority (by telegraph if possible, — expense to be repaid by officer).

2. Until a definite diagnosis can be made, all precautions as to isolation and disinfection must be observed in the same manner as though the case was undoubtedly cholera.

3. All discharges to be disinfected, as above directed ; also all infected objects, — clothes, linen, furniture, floors, etc.

4. Patient to be as thoroughly isolated as possible, with special nurse. If this cannot be done in a private house, then admission should be sought to a hospital or other building prepared for treatment of such cases, and provided with sufficient means of disinfection.

5. Full instructions to be given to nurses as to care and disinfection of their own clothing, hands, eating in same room with the sick, etc.

6. Strict attention must be given that infective material is not placed near wells, either by throwing these discharges not properly disinfected, or by washing in their vicinity soiled clothing, dishes, etc. This precaution applies to all sources of domestic water supply. If there is suspicion that such water supply is already polluted, then the local sanitary authority is to be notified, and measures are to be taken that such suspicious water supplies shall be abandoned and the public warned against their use.

7. If the sick person dies before arrival of physician, the corpse and all personal articles are to be kept under supervision and apart until the arrival of the medical officer, or until action is taken by the local police authority.

8. Investigations should be made for the purpose of ascertaining how the infection has taken place in each case, and whether any opportunity has been given for the spread of the disease (by infected articles, etc.) ; also whether there have been any other suspicious occurrences on the spot.

9. With the occurrence of the first cases in any place, and when the certainty of diagnosis is of the highest importance, a quantity of the discharges (not too small) should be placed in a clean jar or bottle for purposes of a bacteriological examination. In case of necessity a few drops might answer the purpose, or some of the soiled clothing can be used.

10. Physicians skilled in bacteriological examinations can help materially in hastening a decision, if they will at once proceed with this examination, both by microscopical aid and by plate cultures ; and if the case is

found to be cholera, they can at once inform the medical authority of the fact, and, if possible, send him a specimen of the slides or plates made.

In one instance only was the Board called upon to investigate a case in which cholera was suspected to be the cause of death. A woman died at Onset Bay early in September with severe abdominal symptoms, which gave rise to a report of Asiatic cholera. (Onset Bay is a summer resort in Wareham, at the head of Buzzard's Bay.) On investigation it was found that the case was undoubtedly one of simple cholera morbus, of a non-infectious character.

His Excellency Governor Russell requested a conference with the Board on September 1, with reference to the question of a possible epidemic of cholera in the State, and cordially expressed a desire to lend every possible aid which could be furnished to the Board, in its legitimate work of controlling the spread of the disease, should occasion require assistance.

A circular was issued early in September, 1892, directed to the boards of health of all seaport towns in the State, asking information as to what provisions had been made by them "for the detection and management of cases of cholera, and for the prevention of their spread, in case any should arrive" at such ports of entry. In reply to this circular satisfactory replies were received from the boards of health of Boston, Fall River, New Bedford, Gloucester, Salem, Provincetown, Nantucket and Vineyard Haven.

Influenza.

In the annual report of the Board for the year 1889 (twenty-first report, page 307) an account of the epidemic of influenza which occurred in the winter of 1889–90 was presented, in which a detailed statement or history of the epidemic was given, so far as could be collated from the experience of physicians, superintendents of public institutions and persons employing large numbers of men throughout the State. During the following year, and after the subsidence of the epidemic, the population was quite exempt from its reappearance, and there was no recurrence of the epidemic until the spring of 1891, when it again appeared, not only in the United States but in Europe, but in a degree much less severe than the epidemic of 1889–90. Although less severe, the prevalence of the disease continued for a longer time than the epidemic of the previous year. The epidemic began in March and continued until June.

The mortality from influenza and from diseases of the respiratory organs was increased considerably in those months, as is shown in the following table, which may be compared with a similar table upon pages 350–351 of the Forty-ninth Registration Report, 1890.

Mortality from All Causes, and from Influenza, Pneumonia, Phthisis, Bronchitis and Heart Diseases, by Months, in 1891.

1891.

Causes.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Influenza, .	9	9	23	89	107	36	12	9	9	5	6	232	546
Pneumonia, .	474	377	473	577	549	233	136	93	92	177	318	838	4,337
Phthisis, . .	459	405	500	510	504	427	436	422	423	463	405	530	5,484
Bronchitis, .	154	158	166	157	170	121	86	58	73	113	133	269	1,658
Heart diseases,	366	272	315	307	319	244	250	279	255	307	300	378	3,592
Total, . .	1,462	1,221	1,477	1,640	1,649	1,061	920	861	852	1,065	1,162	2,247	15,617
All causes, .	3,578	3,133	3,714	3,802	3,795	3,126	4,070	4,455	3,765	3,714	3,318	4,715	45,185

In the winter of 1891–92 it reappeared with a degree of severity as that of 1889–90. The epidemic began in December, at about the same time or a little earlier than that of 1889–90, and continued for about the same number of weeks.

A very complete history of the epidemics of influenza in England is presented by Dr. Parsons in two special reports of the English Local Government Board, recently published. It appears that the course of these three epidemics extended very nearly over the same periods of time as those in America.

The registrar generals' reports of England and Wales state the deaths from influenza to have been 4,523 in 1890 and 16,686 in 1891; and those which occurred in January and February, 1892, from the same cause, will add largely to these figures. The death rate from this cause amounted to .152 per 1,000 in 1890 and .572 in 1891. With reference to the essential character of this disease, Dr. Thorne states in summing up the investigation: —

The further experience which has been obtained goes strongly to confirm the view that influenza is essentially propagated from person to person. Indeed, the evidence which is now forthcoming tending to show that the disease has followed the lines of human intercourse, so far outweighs any

that has been put forward in favor of its being due to "atmospheric causes" as to suggest that where these have been accepted as accounting for outbreaks, all the circumstances of the local prevalences in question have not been forthcoming.

With reference to the practical points in connection with this subject so far as prophylaxis is concerned, Dr. Parsons says: —

A limit to the possibility of stamping out influenza by isolation has to be pointed out, viz., that such isolation as is practicable cannot be complete. A sick person with an infectious disease must have attendants to supply his needs, and if these attendants be not protected in some way the disease will spread among them, and from them perhaps to other persons outside the place of isolation. Possibly influenza is less liable to spread in the spacious and well-ventilated wards of a well-kept hospital than in an ordinary dwelling-house; but so far as we know there is no means of personal protection; even one attack of the disease affording but a very partial protection against another.

Other difficulties in the way of limiting the spread of influenza by isolation are that the disease is probably infectious in an early stage before its nature is fully declared, and that, as many of the patients are adult bread-winners, it would be difficult to detain them sufficiently long to ensure that infectiousness had ceased.

With reference to the practicability of notification of cases of influenza as a disease dangerous to the public health, and with reference to the closing of schools, Dr. Parsons further says: —

I do not think that the compulsory notification of influenza affords much prospect of utility, though there may be districts, *e. g.*, small and comparatively isolated health resorts, in which it might be worth while to make trial of it.

The closing of schools in presence of influenza is another precaution of which mention may be made. The mere exclusion of scholars from households known to be infected would probably fail, for the reason that many of the cases are not heard of, and that the disease is infectious in an early and often unrecognized stage. In many instances schools have had to be closed during the prevalence of an epidemic of influenza, owing to a large number of the teachers and scholars being prostrated with it. But in some few instances schools have been closed as a precautionary measure at the outset of an epidemic, and in one case in which an appeal was made, the Board expressed the view that the order to close the school under these circumstances was not unreasonable.

Trichinosis.

During the past ten years occasional slight outbreaks of this disease have occurred in Massachusetts, in which one or more persons and in some cases one or two families have been involved; but no fatal cases had occurred for more than twenty years until February, 1892, when notice was sent to the Board of the existence of an epidemic of this character of somewhat alarming extent in the town of Colrain, in the northern part of Franklin County, not far from Shelburne Falls. The secretary immediately visited the town and saw many of the persons who were sick (two had already died), and found that the diagnosis of the attending physicians was undoubtedly correct, the symptoms corresponding quite closely with those of other preceding outbreaks of smaller proportions, which have been detailed in previous reports. From one of the fatal cases portions of red muscular tissue were obtained, and examined both by the attending physician and by experts of the Board, and were found to contain large numbers of free trichinæ.

The following statement of these cases by the attending physician, Dr. Drew of Shelburne Falls, is reprinted from the published transactions of the Massachusetts Medical Society for 1892: —

During the latter part of January and February, 1892, there occurred in the hill-town of Colrain, Franklin County, an outbreak of trichinosis, which, so far as I know, exceeded, in the total number of cases and the number of deaths, any previously recorded outbreak of this disease at one time and place in the New England States. Colrain has several cotton manufacturing villages within its limits, and the one where this epidemic occurred consists of a cotton mill employing about one hundred hands, a long brick block containing nineteen tenements in which all the operatives dwell, and two or three isolated houses occupied by the superintendent and the few Americans employed about the mill.

The inhabitants of the block are all foreigners, — French Canadians, Austrians and Germans from Bavaria and Würtemburg, which latter have to a large extent replaced, during the last few years, the French Canadians who formerly furnished most of the workers in the mill. The population is mainly young, there being few old people, and frequently the whole family works in the mill. Most of these Austrians and Germans have been in this country but a short time, and have learned very little English. I used the German language in communicating with them, but their dialects are nearly unintelligible, and the early history of the cases was therefore not well understood in the beginning of my attendance. Perhaps, if an

interpreter had been employed, an earlier diagnosis might have been reached. This outbreak occurred toward the close of the influenza epidemic, and the first physician who was called to the cases mistook them for cases of influenza, although he was much puzzled by some of the symptoms. He soon fell a victim to influenza himself, and was unable to observe the further course of the cases. It was for this reason, therefore, that in many of the cases of moderate severity no physician at all was employed, and some of the severest cases were not attended by a physician until the disease was well advanced, as they thought their malady was the prevailing grip, and not of a serious nature. My experience with the disease began on February 8, when I saw two cases in the same family. On February 12, I met another case also in the same family. On February 14, I was called to two other families, in one of which there were three cases and in the other a single case. These seven cases were all that I attended, and it was not till several days later that I became aware of the fact that there were, or had been, many cases of a similar nature among the population of the block. I will relate briefly the history of the cases which came under my observation.

Case I. — Frederick H., age twenty-one, single, native of Bavaria. Had been sick ten days; complained of loss of appetite and general weakness, and some stiffness about the legs and ankles, which had been swollen slightly, but the swelling had then disappeared; his face and eyelids had been swollen a few days previously, but this had also disappeared; did not sleep well at night; bowels moved once every day; no pain or tenderness anywhere; pulse 100, temperature 103°. He remained in bed about a week, with a temperature ranging from 101° to 103°, which gradually became normal, and there was no increase in the severity of the other symptoms. In this case there were no gastro-intestinal symptoms at any time, and the only characteristic signs of trichinosis were the early œdema of the face and eyelids, and the very slight stiffness of the legs. The temperature was higher than in some of the other cases which were much more severe in the muscular symptoms, and generally the amount of fever seems to be no guide to the gravity of the disease, as a mild case may have a temperature of 103° for several days, while in a severe case which is to end fatally the thermometer may never register above 101°.

Case II. — Henry H., age nineteen, brother of the preceding, taken sick about the same time. Had had œdema of face and eyelids a few days previously, which had disappeared. Some stiffness of arms and legs, which had been swollen; some pain on motion; dorsal decubitus, and inability to sit up or turn over in bed; occasionally slight pains in abdomen; bowels constipated; respiration 30 per minute, pulse 90, and temperature 101°; sweat considerably; appetite lost, and some difficulty in swallowing. The muscular symptoms increased in severity during the progress of the disease; dyspnœa, difficult deglutition and slowness of speech becoming

more pronounced, and the feet and legs very œdematous, but there was not very much pain or tenderness in the muscles. He had considerable pain and tenderness in the abdomen, and always felt better after his bowels had been moved by cathartics. This was one of the severest cases which recovered, and it was about six weeks from the beginning of his illness before he was able to sit up. He made a rapid convalescence, however, and is now quite well. The temperature in this case never rose above 102°, and frequently was only 100° during the period of greatest severity. Insomnia was quite troublesome.

These two cases had been diagnosticated as "grip" a few days previously, which saved me from embarrassment, as I was not asked to give my diagnosis; but I thought they resembled rheumatism more than any other disease.

Case III. — The father of the two preceding cases. Was not seen till my second visit to them on February 12. He was a very voluble talker, but his Bavarian dialect was nearly unintelligible, and I could only make out that he suffered from pain in the bowels, diarrhœa and pain in the legs, which were not œdematous at that time. As I could not understand him well enough to elicit the history of the trouble, it did not strike me at the time that his disease was the same as that from which his sons were suffering. His pulse rate and temperature were normal, and continued so during all the time he was sick. His appetite was good throughout, and he persisted in being up and walking around. His diarrhœa continued for three or four weeks, and he had a good deal of pain in the abdomen. His feet and legs became œdematous, and he complained of stiffness and pain in the muscles. He also had had œdema of face and eyelids in the beginning of the attack. At first I considered this case as one of intestinal derangement. After I had made the diagnosis of trichinosis, I learned that three other members of this family, two girls and a boy, had been ill with the same symptoms and at the same time, from one week in the mildest case to three weeks in the severest.

Case IV. — Mrs. E., age twenty-eight, native of Austria. Visited first on February 14, six days after seeing the first case, and it was the first intimation that I had that there were other cases in the block similar to those already described. Mrs. E. had been sick three weeks, and her disease had, in the early stage, like that of the first two cases, been diagnosticated "grip." She had rather severe gastro-intestinal symptoms, vomiting and diarrhœa; abdomen bloated and painful on pressure; legs and arms swollen, and stiffness and soreness of the muscles all over the body; dyspnœa considerable; perspiration constant; pulse 120; temperature 103.5°; insomnia very distressing; mind clear. After a day or two the vomiting ceased and the diarrhœa became less severe, but continued to the end. The other symptoms grew worse daily, the œdema increasing till the legs and thighs were enormously enlarged and of a board-like induration, and

the muscular pains became so excruciating that large doses of morphine were necessary to afford any relief. The muscular stiffness was so great that she was unable to move any portion of the body but the arms, and those with difficulty. Dyspnœa increased till the respiration rate was 60 per minute, and deglutition became more and more difficult, till fluids were regurgitated through the nose. There was also stiffness of the muscles of mastication and difficulty in opening the mouth. The pulse varied from 120 to 130 per minute and the temperature from 103° to 104° till the day of her death, when she went into a state of collapse and the temperature fell.

The urine was examined, with following result: reaction strongly acid, color very dark; specific gravity 1.040; albumen 1 per cent. Large amount of sediment, consisting of urates and what seemed under the microscope fat globules, and granular detritus. No casts were found.

Her death occurred on February 23, after an illness of about four weeks.

The next three cases were seen for the first time on the same date as the last one, and were all in one family, and showed the three grades of severity, — mild, moderate and fatal.

Case V. — The youngest, John R., complained only of languor and weakness, and some stiffness. Was able to be up and around the house, and recovered in about three weeks.

Case VI. — E. R., his brother, was more severely affected, although not confined to the bed at any time. His afternoon temperature was usually 102°, and at night he sometimes had "phantasieen," as he termed it. His legs became œdematous, and he suffered considerably from pain in the muscles, particularly those of the chest. He also recovered after three or four weeks' illness.

Case VII. — Mrs. R., age twenty-eight, wife of E. R., had been ill about two weeks, as her husband and her brother, but they had all continued to work in the mill till within two or three days of my seeing them. She was confined to the bed with symptoms similar to those of the others. Insomnia was a prominent symptom with her, as well as with her husband. Considerable œdema of lower limbs, and pain and tenderness in the muscles on motion; temperature 101°, pulse 100. This woman was about six months pregnant with her first child, and informed me on February 19 that she no longer felt any fœtal movements, and feared the child was dead. In the latter part of February Mrs. R. passed from my care into that of another physician, and finally died on March 17, having been ill about six weeks.

After seeing these last four cases on February 14, I began to realize that there must be an epidemic of some disease; but it was not till February 20, when I met the superintendent of the mill going his rounds among the sick, that I learned that there were many other cases of a similar nature in the block, one of which, a Canadian Frenchman, Charles B., had died that day, after an illness of three weeks, his disease having been diagnos-

ticated "typhoid fever." This was the first fatal case, Mrs. E. and Mrs. R. being the next two victims, and B.'s wife, who was taken ill soon after her husband, was the fourth and last fatal case. Mrs. B. lived till March 22, about seven weeks from the onset of the symptoms.

I obtained some pieces of muscular tissue from the body of Mrs. B., and trichinæ were found to be very numerous in them all. Four weeks previously, when Mrs. E. died, I had just made the diagnosis, and endeavored to get some muscular tissue from her, but the husband's permission could not be gained.

Another French Canadian woman, Mrs. R., age forty-four, was the first person in the block to be taken ill with the symptoms of trichinosis, and the last to recover therefrom. She was not very strong when attacked by the disease, and was more prostrated than any of the other cases which recovered; she had a persistent diarrhœa for twelve weeks, but is now gaining.

These are all the cases, I believe, which were seen by a physician at some stage of the disease. For information in regard to the other cases I am indebted to the superintendent of the mill, Mr. A. H. W., who observed them closely, and made frequent visits to them while they were confined to the house.

Mr. W. states that there were twelve others who were ill enough to be absent from work in the mill, for from one to three weeks in various cases. Of these, four were in one family, three each in two families, and one each in two others, all of whom had œdema of face and eyelids, weakness, pains and more or less gastro-intestinal symptoms. There were at least fourteen others who had œdema of face and eyelids and did "not feel well," but kept at work or lost but two or three days.

The duration of the disease from the time of the ingestion of the trichinæ must be reckoned as longer than would appear from the mill records, for they all, even the severe cases, worked till œdema of the face and eyelids appeared, which is said to occur on the eighth day, and I think the gastro-intestinal symptoms must have been very light in most of the cases.

Besides these thirty-six cases enumerated, there were undoubtedly many other mild cases among the children and others who do not work in the mill, as Mr. W. tells me many of them had œdema of the eyelids and face; and this is such a noteworthy and characteristic symptom of trichinosis, that in the presence of an epidemic like this it may be considered almost pathognomonic.

In addition to the cases in the block, a few mild ones were reported in a village a mile distant, so that I should estimate that at least fifty persons were more or less affected with the symptoms of trichinosis during this epidemic.

As soon as a correct diagnosis was reached, efforts were made to trace the source of the diseased pork, but it was so long after the disease broke

out that none of it could be discovered. Not much help or co-operation can be obtained from butchers in this respect, for they seem to feel that blame will attach to themselves and that their trade will be lessened if the facts are known, — which seems to be justified in the present instance, as it has been nearly impossible to sell any form of pork or sausage to the inhabitants of the block since the epidemic. From the inquiries made, it seems most probable that the trichinæ ingested were contained in Bologna sausage. It is admitted by all that they used this particular form of sausage, and large amounts were consumed in the families where the fatal cases occurred. It is eaten just as it comes from the manufacturer, at whose hands it does not receive much cooking, as this impairs the flavor; and it was a favorite dish with the three women who died, as they worked in the mill and had little time for cooking. The husband of Mrs. E. never ate it, however, and, although he ate pork in other forms, never showed any symptoms of trichinosis. Mr. R. states that before they were taken sick they had some Bologna sausage which he thought tasted badly, and therefore did not eat much of it; but his wife liked it, and ate a large quantity, with a fatal result. Mrs. R. says that she ate some sausage which did not taste well and made her sick. These sausages, which are very cheap, were obtained from the local butchers, who get them from Chicago.

As Secretary of Agriculture Rusk has established an official laboratory in Chicago for the examination of pork intended for export, a larger proportion of trichinous meat will be sold in the American market, and the disease will be likely to prevail to a greater extent than heretofore. What becomes of the pork condemned as unfit to be exported? Is it worked up into these cheap sausages which were the probable cause of this epidemic?

A. Seibert of New York states that investigations show that from five to sixteen per cent. of American hogs contain trichinæ, while in Germany only one out of two thousand contains them. The chances of infection are therefore far greater in this country than in Germany, although the disease has been of more frequent occurrence there, from the fact that the Germans are much more in the habit of eating pork and sausages in a raw or underdone condition.

Here was an epidemic of more than fifty cases, with four deaths, witnessed by three physicians, yet it was not until the second death and three or four weeks from its commencement that a correct diagnosis was reached; and it is possible that if there had been no fatal cases the diagnosis of trichinosis might never have been made, and this outbreak might have passed unrecognized and unrecorded. This suggests the importance of directing the attention of physicians to the disease, and the necessity for them to make themselves familiar with its symptoms and course, and its differential diagnosis from those diseases for which it is most liable to be mistaken; so that they may be able to make the diagnosis from the clinical

symptoms, which should be comparatively easy in any case of moderate severity, and will be rendered positive by finding the trichinæ in the suspected meat or in the stools or muscles of the patient. Yet in a large proportion of the cases reported, the disease is at first supposed to be something else, and many cases probably escape detection altogether. It is the most widely disseminated and deadly of all known parasitic diseases, and its early detection is of the utmost importance, not only to render treatment effective in the case of those already affected, but to prevent other persons from contracting the disease from the same source.

Grawitz, Virchow's assistant, states that trichinæ were found, on autopsy, in one-third of the cases of so-called muscular rheumatism. Probably the proportion of cases would not be so great in this country; but it is quite likely that we may at times be treating former sufferers from trichinosis for rheumatism, when their symptoms are in reality due to the encysted trichinæ. I have had one such case myself, an American, one of the Springfield cases reported to this society twenty-five years ago by Dr. Calkins; this man two years ago had a severe attack of what I then considered muscular rheumatism, but now suppose to have been due to the presence of trichinæ which had been there twenty-three years. And when we consider the immense numbers of the parasites, and how thickly the muscles are studded with them, it is surprising that, after migration has ceased and they have become encysted, the muscles should so quickly recover their function and show so little effect from their presence. So far as I know, but two or three of those who suffered in this epidemic have had symptoms, since their recovery, which might be attributed to the presence of the trichinæ.

In Germany many more cases of trichinosis are reported than in this country, which must be partly due to the fact that obligatory meat inspection is practised, and the attention of physicians more generally directed to the detection of the disease; since in Berlin in 1877, the year before meat inspection became obligatory, only six cases of trichinosis in man were reported, but in 1878, after obligatory meat inspection was established and the attention of physicians called to the subject, one hundred and two cases were reported, with eight deaths.

The occurrence of so great a number of cases in one small community in our midst will serve to show how liable we are to encounter cases of the disease, and the importance of directing our attention to its detection, when we shall probably find that trichinosis is of more frequent occurrence here in Massachusetts than is shown by statistics.

Soon after the occurrence of this outbreak several other cases were reported from Roxbury, with one death, part of which were reported by Dr. C. W. McDonald in the "Boston Medical and

Surgical Journal" of June 2, 1892. The secretary visited these cases, and found that they presented similar symptoms to those which were observed at Colrain, but generally in a milder degree among those who survived. In these cases the cause of illness was undoubtedly due to a ham which was purchased and eaten either raw or partially cooked. The man who died ate his portion as part of a lunch which was sent to him at his place of work. A portion of this ham was sent to Professor Mark, and it was found to contain trichinæ in abundance.

The following extract is from the published report of the attending physician, already mentioned: —

About the last of March a patient came to my office complaining of some purging with abdominal pains. Having no other serious symptoms, I concluded that the trouble was caused by some indigestible irritant, and prescribed accordingly. Two days later I was called to his boarding-house to see the proprietor, who was in bed and seriously ill. His symptoms were somewhat similar to those of patient No. 1, but much more exaggerated, and, in addition, he had a temperature of 102° F., bulging of eyes, headache, and "pains all over his body."

Being assured of no unusual diet in the household, and consequently ignorant of the true nature of the disease, I treated the matter symptomatically and expectantly, and left with typhoidal thoughts agitating my mind. Next day my second patient's sufferings were intensified; temperature 104.5°. Still I postponed my diagnosis.

And now, with the invasion of other members and friends of the family, to the number of fifteen, came the solution of what thus far had proved a mystery. About ten days previously, the family larder had been re-enforced by the addition of a partially smoked ham. A neighboring family was also similarly supplied, and sandwiches, of the raw pork from both hams, had been more or less freely partaken of. Every one who had eaten of them was, in about forty-eight hours, similarly affected, some more seriously than others, the degree of affliction not at all in proportion to the quantity eaten. One visitor at my patient's house, who had eaten two sandwiches, died in about ten days, despite the best medical attendance.

In connection with this report, I may add that the microscopical examination of the infected pork revealed numerous and active trichinæ.

The foregoing accounts of outbreaks of trichinosis serve to emphasize the warnings which the Board has published in several of its preceding reports relative to the necessity of *cooking all pork thoroughly before it is used as food.*

Since 1879 the Board has had examinations made of 12,567 hogs from various sources, of which number 791, or 6.3 per cent., were found to be trichinous.

Since there appeared to be reason for believing that the epidemic at Colrain might have been due to the eating of sausages of some sort, the Board directed an examination of sausages to be made, such as were offered for sale in the markets throughout the State. A collection was therefore made of Bologna, Frankfort and common New England sausages in twenty-five cities and towns in all parts of the State. These three kinds of sausages were represented in this collection in about equal numbers. The whole number collected was 367, from about 125 different markets and shops. They were all carefully examined by an expert (Mr. A. Weysse of Harvard University), and the result was almost negative, only one specimen, a New England sausage, being found to contain trichinæ. In this sample they were found in great abundance.

It appeared that considerable quantities of beef as well as pork are employed in the manufacture of the so-called Bologna sausages in this country.

Registration of Vital Statistics.

It has been customary to present in this general report a summary of the statistics of births, marriages and deaths of the year previous, since the vital statistics of any community form the basis of sanitary work. The subject will be presented more fully this year than it has been customary to present it in previous reports.

As a basis for all accurate deductions in the matter of registration, a statement of the population is essential. In intercensal years an estimate becomes necessary, and in making this estimate it has been customary to adopt the practice usually followed in most enlightened countries; and that is, to assume that the rate of increase of a past series of years (an intercensal period, for example) is maintained up to the year for which the estimate is made. It has usually been found that Dr. Farr's rule (the geometric rate of increase) in the long run gives the most accurate results. Hence his method is adopted in this summary. Upon this basis the estimate of the population adopted for 1891 is 2,303,536.

There were 63,004 births reported during the year 1891, 21,765 marriages, 45,185 deaths and 2,222 still-births.

The ratios to the estimated living population were as follows: —

Birth rate,	27.35	per 1,000 of the living population.
Marriage rate (marriages),	9.41	" " " " "
Persons married,	18.82	" " " " "
Death rate,	19.62	" " " " "
Excess of birth rate over death rate,	7.73	" " " " "

As compared with previous years, the estimated birth rate was higher than that of any year since 1874.

The estimated marriage rate was only exceeded since 1883 by that of 1887, which was 18.90 per 1,000 (persons married).

The estimated death rate was higher than those of 1889 and 1890, but lower than those of 1887 and 1888.

Births.

The births, 63,004 in all, were greater in number than those of any previous year. The number of still-births was 2,222. The largest number of births in a single month occurred in July. The births in the 30 cities were 43,828, as compared with 39,639 in 1890, an increase of 10.6 per cent. Those in the remainder of the State were 19,176, as compared with 18,138 in 1890, an increase of 5.7 per cent.

The sex of children born in 1891 showed a greater ratio of males to females than has prevailed for the past eighteen years, the males being in the ratio of 106 9 to each 100 females.

Marriages.

The number of marriages (21,675) was greater than that of any previous year. The greatest number, 2,723, took place in November; and the least number, 999, in March.

A noteworthy point in connection with the marriages is the gradual increase in the age at marriage both of all males and females, as well as for men and women marrying for the first time. The approximate age of the men who married in 1891 was 28.85 years; that of women was 25.53 years; that of men marrying for the first time was 26.82 years; that of women marrying for the first time was 24.28 years. Comparing the five-year periods 1871–75 with 1886–90, there is found to be a slight increase in the age of both men and women at the average time of marriage.

Deaths.

The number of deaths registered for the year 1891 was 45,185, which was greater than that of any previous year. There was an

increase in the number of deaths in each of the counties except Berkshire, Dukes, Essex, Hampden, Nantucket and Norfolk, as compared with those of the previous year. In Nantucket the number of deaths was the same as in the preceding year.

Infant Mortality. — During the year 1891 10,186 infants under one year died, which was 22.54 per cent. of the total number of deaths, a greater percentage at this period of life than had occurred since 1874. The percentage of deaths under five years of age (31.58) was less than that of any previous year since 1885. The mortality rate of infants under one year was less than that of the previous year, as compared with the number of births, and was also slightly less than the average of the twenty-year period (1871–90).

The deaths of centenarians during 1891 were 25 in number, of which 7 only were of native birth.

Causes of Death. — The number of deaths the causes of which were not registered in 1891 was 407, which was .9 of one per cent. of the total number of deaths, and was the smallest ratio of this class since the beginning of registration.

The percentage from the class of local diseases was greater than the average of the ten-year period 1882–91, that of the deaths from violence was the same as the average, while that of each of the other general classes was less.

Percentage of Causes of Death, by Classes. — Ten Years.*

Years.	Classes.				
	Infectious.	Constitutional.	Local.	Developmental.	Violent Deaths.
1882,	21.8	24.0	38.7	11.2	4.3
1883,	20.6	23.8	40.2	10.9	4.5
1884,	21.1	23.8	39.7	10.9	4.5
1885,	19.0	23.7	42.7	10.7	3.9
1886,	18.5	24.2	42.0	11.0	4.2
1887,	19.7	22.6	42.7	10.7	4.2
1888,	19.1	21.8	43.7	10.2	4.0
1889,	19.2	21.5	43.5	10.5	4.0
1890,	18.6	21.2	44.8	10.1	4.2
1891,	18.4	20.2	46.9	10.3	4.2
Average,	19.6	22.7	42.8	10.7	4.2

* Excluding deaths from unspecified causes, and still-births.

Mortality from Prominent Infectious Diseases. — Ten Years.

Years.	Diseases.									
	Typhoid Fever.	Whooping-cough.	Croup.	Diphtheria.	Measles.	Scarlatina.	Dysentery.	Cholera Infantum.	Small-pox.	Totals.
1882,	1,079	265	491	1,280	68	318	398	2,159	45	6,103
1883,	860	137	530	1,091	321	575	336	1,941	5	5,796
1884,	875	410	562	1,084	75	627	254	2,081	3	5,971
1885,	768	184	520	1,003	313	587	253	1,852	19	5,499
1886,	800	271	505	1,053	180	331	243	1,931	-	5,264
1887,	922	232	532	1,096	455	594	266	2,131	3	6,231
1888,	943	245	500	1,331	219	504	248	2,195	8	6,193
1889,	891	310	484	1,730	171	185	299	2,156	4	6,232
1890,	835	363	387	1,239	114	196	220	2,491	1	5,846
1891,	821	219	311	907	236	246	234	2,771	1	5,746
Average,	879	263	482	1,181	188	416	274	2,170	9	5,862

In the foregoing table are presented the numbers of deaths from each of the prominent infectious diseases for a period of ten years, together with the average annual number of each for the period.

The group of diseases presented in this table comprises most of those which are considered as preventable, and hence are of vital interest to the sanitary official whose duties are largely concerned in the attempt to diminish the rate of sickness and mortality from infectious diseases.

Small-pox. — There was but 1 death from small-pox during the year, as compared with 1 in 1890, 4 in 1889 and 8 in 1888. Compared with the living population, the death rate from this disease for the twenty years, 1852–71, was 1.12 per 10,000, and for the twenty years, 1872–91, it was .54 per 10,000, — a very decided reduction, notwithstanding the serious epidemic of 1872, in which year occurred nearly one-half of the deaths reported from this disease for the second period in question. The percentage of deaths from this cause to deaths from all causes for the same periods was .59 of one per cent. for the former and .27 of one per cent. for the latter period.

Statistics of Certain Diseases, Massachusetts, 1872–91.

Deaths, and Ratios compared with Population and Mortality from All Causes.

	Small-pox.			Measles.			Scarlet-fever.			Diphtheria and Croup.			Typhoid Fever.			Cholera Infantum.			Consumption.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.
1872,	1,029	6.7	2.94	428	2.8	1.22	1,377	9.0	3.93	753	4.9	2.16	1,703	11.1	4.86	3,254	21.2	9.29	5,556	36.2	15.86
1873,	668	4.3	1.97	180	1.1	.53	1,472	9.4	4.34	745	4.7	2.20	1,406	8.9	4.15	2,553	16.2	7.53	5,556	35.3	16.38
1874,	26	.2	.08	161	1.0	.50	1,382	8.6	4.33	913	5.6	2.86	1,147	7.1	3.6	2,322	14.4	7.28	5,284	32.8	16.57
1875,	34	.2	.09	233	1.4	.67	1,684	10.2	4.81	1,880	11.4	5.31	1,059	6.4	3.02	2,606	15.8	7.45	5,738	34.7	16.40
1876,	31	.2	.09	47	.3	.14	1,222	7.3	3.68	3,294	19.6	9.92	881	5.3	2.65	2,087	12.4	6.29	5,327	32.2	16.05
1877,	24	.14	.08	135	.8	.44	467	2.7	1.49	3,178	18.7	10.14	814	4.8	2.59	1,927	11.3	6.15	5,457	32.0	17.41
1878,	2	.01	.01	305	1.8	.97	404	2.2	1.29	2,517	14.6	8.04	679	3.9	2.16	1,573	9.1	5.02	5,334	30.8	17.04
1879,	7	.04	.02	19	.1	.06	850	4.8	2.67	2,293	13.1	7.21	637	3.6	2.00	1,349	7.7	4.24	5,223	29.7	16.42
1880,	38	.21	.11	236	1.3	.67	574	3.2	1.63	2,394	13.4	6.78	882	4.9	2.50	2,118	11.9	6.00	5,494	30.8	15.57
1881,	47	.25	.13	230	1.3	.63	397	2.2	1.09	2,383	13.1	6.54	1,072	5.9	2.94	1,861	10.3	5.10	5,886	32.4	16.14
1882,	45	.24	.12	68	.4	.18	318	1.7	.86	1,771	9.6	4.81	1,079	5.8	2.93	2,159	11.7	5.87	5,865	31.8	15.93
1883,	5	.03	.01	321	1.7	.85	575	3.1	1.52	1,621	8.6	4.29	860	4.6	2.28	1,941	10.3	5.14	5,931	31.6	15.71
1884,	3	.01	.01	75	.4	.20	627	3.3	1.69	1,646	8.6	4.45	875	4.6	2.36	2,081	10.9	5.62	5,798	30.4	15.67
1885,	19	.10	.05	313	1.6	.82	587	3.0	1.54	1,523	7.8	3.98	768	3.9	2.02	1,852	9.5	4.86	5,955	30.7	15.63
1886,	–	–	–	130	.6	.35	331	1.7	.89	1,558	7.8	4.18	800	4.0	2.15	1,931	9.7	5.18	5,897	29.5	15.83
1887,	3	.01	.007	455	2.2	1.12	594	2.9	1.46	1,628	7.9	3.99	922	4.5	2.26	2,131	10.4	5.23	5,871	28.6	14.40
1888,	8	.04	.02	219	1.0	.52	504	2.4	1.20	1,831	8.7	4.35	943	4.5	2.24	2,195	10.4	5.21	5,728	27.1	13.61
1889,	6	.03	.01	171	.8	.41	185	.8	.44	2,214	10.2	5.30	891	4.1	2.13	2,156	9.9	5.16	5,581	25.7	13.36
1890,	1	.004	.002	114	.5	.26	196	.9	.45	1,626	7.3	3.74	835	3.7	1.92	2,491	11.1	5.72	5,791	25.9	13.31
1891,	1	.004	.002	236	1.02	.52	246	1.06	.54	1,218	5.3	2.69	821	3.6	1.82	2,771	12.0	6.13	5,484	23.8	12.14

STATISTICS OF CERTAIN DISEASES, MASSACHUSETTS, 1872–91 — Concluded.

Deaths, and Ratios compared with Population and Mortality from All Causes — Concluded.

	PNEUMONIA.			WHOOPING-COUGH.			CANCER.			KIDNEY DISEASES.			HEART DISEASES.			BRAIN DISEASES.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.
1872,	2,295	15.0	6.55	363	2.4	1.04	542	3.5	1.55	376	2.4	1.07	1,202	7.8	3.43	2,884	18.8	8.24
1873,	2,097	13.3	6.18	264	1.7	.78	611	3.9	1.80	460	2.9	1.35	1,236	7.9	3.64	2,651	16.9	7.82
1874,	2,386	14.8	7.49	449	2.8	1.41	585	3.6	1.83	463	2.9	1.45	1,272	7.9	3.99	2,545	15.8	7.98
1875,	2,940	17.8	8.40	242	1.5	.69	593	3.5	1.69	509	3.1	1.45	1,331	8.1	3.80	2,715	16.4	7.76
1876,	2,447	14.6	7.37	192	1.1	.58	657	3.9	1.98	488	2.9	1.47	1,335	8.0	4.02	2,627	15.7	7.92
1877,	1,972	11.6	6.29	369	2.2	1.18	646	3.8	2.06	535	3.1	1.71	1,355	7.9	4.32	2,649	13.5	8.44
1878,	2,171	12.6	6.93	400	2.3	1.28	807	4.7	2.58	615	3.6	1.96	1,442	8.4	4.61	2,909	16.8	9.29
1879,	2,647	15.0	8.32	302	1.7	.95	862	4.9	2.71	693	3.9	2.18	1,515	8.6	4.76	2,946	16.8	9.26
1880,	3,076	17.2	9.71	230	1.3	.65	928	5.2	2.63	698	3.9	1.98	1,726	9.7	4.89	3,364	18.8	9.53
1881,	2,967	16.4	8.14	217	1.2	.59	949	5.2	2.60	825	4.5	2.27	1,937	10.7	5.31	3,355	18.5	9.20
1882,	2,932	15.9	7.97	265	1.4	.72	987	5.3	2.68	877	4.7	2.38	2,025	11.0	5.50	3,393	18.4	9.22
1883,	3,045	16.2	8.07	137	.7	.36	1,026	5.5	2.72	959	5.1	2.54	2,153	11.5	5.70	3,562	19.0	9.44
1884,	2,646	13.7	7.15	410	2.1	1.11	1,060	5.6	2.86	1,000	5.2	2.70	2,117	11.1	5.72	3,669	19.2	9.92
1885,	3,468	17.9	9.10	184	.9	.48	1,087	5.6	2.85	1,088	5.6	2.86	2,227	11.5	5.85	3,894	20.0	10.22
1886,	2,836	14.2	7.61	271	1.4	.73	1,104	5.5	2.96	1,135	5.7	3.05	2,325	11.6	6.24	3,844	19.2	10,32
1887,	3,348	16.3	8.21	232	1.1	.57	1,174	5.7	2.88	1,120	5.4	2.75	2,690	13.1	6.60	4,257	20.7	10.44
1888,	3,716	17.6	8.83	245	1.2	.58	1,275	6.0	3.03	1,318	6.2	3.13	3,061	14.5	7.27	4,522	21.4	10.74
1889,	3,440	15.8	8.23	310	1.4	.74	1,325	6.1	3.17	1,258	5.8	3.01	3,280	14.2	7.85	4,313	19.8	10.32
1890,	4,038	18.0	9.28	363	1.6	.83	1,387	6.2	3.19	1,273	5.7	2.92	3,417	15.3	7.85	4,389	19.6	10.08
1891,	4,337	18.8	9.60	219	.9	.48	1,395	6.1	3.09	1,474	6.4	3.26	3,592	15.6	7.95	4,711	20.5	10.42

Measles. — The number of deaths from measles in 1891 was 236, which was only exceeded in the past decade in 1883, 1885 and 1887. Compared with the estimated living population, the mortality rate from measles was 1.02 per 10,000, while in 1890 it was .5 and in 1889 .8. The mortality rate as compared with the deaths from all causes was .52 of one per cent., as compared with .26 in 1890 and .41 in 1889.

Scarlet-fever. — The number of deaths from scarlet-fever in 1891 was 246, or 50 more than those of the previous year and 61 more than those of 1889, but much less than those of either 1888 or 1887, which were respectively 504 and 594. As compared with the estimated living population, the mortality from scarlet-fever was 1.06 per 10,000, that of the previous year being .87, and of 1889 .85. The mortality of the past decade from this cause has greatly diminished, as compared with that of the two previous decades. As compared with the total mortality, the deaths from scarlet-fever were .54 of one per cent., as compared with .45 in 1890, .44 in 1889 and 1.20 in 1888.

Diphtheria and Croup. — The number of deaths from these causes in 1891 was 1,218, which was less than the mortality from the same causes for any year since 1874. The ratio of mortality was 5.3 per 10,000 of the living population, while that of 1890 was 7.3 and that of 1889 10.2. As compared with the mortality from all causes, the mortality from diphtheria and croup was 2.69 per cent. and 3.74 per cent. in 1890, and 5.30 per cent. in 1889.

Typhoid Fever. — The deaths from typhoid fever in 1891 were 821, which was less by 14 than those of 1890, and 70 less than those of 1889. As compared with the estimated living population, the mortality rate from this cause was 3.6, while that of the previous year was 3.7 and that of 1889 was 4.1. The percentage of the total mortality was 1.82, as compared with 1.92 in 1890 and 2.13 in 1889. No deaths were reported in Nantucket County, and one only in Dukes County. There was a decrease in the deaths from this cause as compared with those of 1890 in the counties of Barnstable, Essex, Franklin, Hampden and Middlesex.

Diarrhœal Diseases (diarrhœa, dysentery, cholera infantum, cholera and enteritis). — The number of deaths from these combined causes in 1891 was 4,611, which was 441 greater than those of 1890 from the same causes, and 878 more than the average of the decade (1882–91). The deaths from these causes constituted

10.2 per cent. of the total mortality, as compared with 9.6 in 1890, and were also 20 per 10,000 of the estimated living population. The increase consisted mainly in the deaths from cholera infantum, which were much more than those of any previous year, except 1872, when the mortality from this cause was 3,254, or 21.2 per 10,000.

Phthisis. — The number of deaths from phthisis in 1891 was 5,484, as compared with 5,791 in 1890 and 5,581 in 1889. The deaths from this cause were in the ratio of 23.8 per 10,000 of the estimated living population, and also constituted 12.1 per cent. of the total mortality. There was an increase in the number of deaths from this cause in Barnstable, Dukes, Franklin, Hampshire, Middlesex and Norfolk counties, as compared with the mortality of the previous year, and a decrease in the remaining counties.

Pneumonia. — The number of deaths from pneumonia in 1891 was 4,337, which was 299 more than those of 1890, and 897 more than those of 1889. The death rate from this disease was 18 8 per 10,000 of the living population, and was also 9.6 per cent. of the mortality from all causes, indicating in each instance an increase over the ratio of the preceding year. There was an increase in the mortality from this cause in each county except Essex, Hampden and Norfolk, over the deaths of the previous year from the same cause.

Whooping-cough. — The deaths from whooping-cough in 1891 were 219, or 144 less than those of 1890 from the same cause. They were in the ratio of .9 per 10,000 of the living population, as compared with 1.6 in 1890 and 1.4 in 1889. They also constituted .48 of one per cent. of the total mortality, as compared with .83 in 1890 and .74 in 1889. No deaths were reported from this cause in the island counties.

Cancer. — The number of registered deaths from cancer was 1,395, as compared with 1,387 in 1890 and 1,325 in 1889. There has been a gradual and quite uniform increase in the mortality from this cause during nearly the whole period of registration. The death rate per 10,000 of the estimated living population from this cause was 6.1, as compared with 6.2 in 1890, 6.1 in 1889 and 6 in 1888. The percentage of the total mortality was 3.09, as compared with 3.19 in 1890 and 3.17 in 1889.

Kidney Diseases. — Diseases of the kidneys caused 1,474 deaths in 1891, which was 201 more than those of 1890 and 216 more than

those of 1889. The death rate per 10,000 of the living population from this cause was 6.4, as compared with 5.7 in 1890 and 5.8 in 1889. The percentage of the total mortality was 3.26, as compared with 2.92 in 1890 and 3.01 in 1889.

Heart Diseases. — The number of deaths registered as due to heart disease in 1891 was 3,592, while those of 1890 were 3,417 and those of 1889 3,280. The death rate per 10,000 of the living population was 15.6, as compared with 15.3 in 1890 and 14.2 in 1889. The percentage of the total mortality was 7.95, as compared with 7.85 in 1890 and the same in 1889.

Brain Diseases. — Under this title are included the deaths registered as deaths from apoplexy, paralysis, insanity, softening of the brain, cephalitis and other unspecified brain diseases, the number from these causes combined being 4,711 in 1891, as compared with 4,389 in 1890 and 4,313 in 1889. The death rate per 10,000 of the living population from this group of causes was 20.5, as compared with 19.6 in 1890 and 19.8 in 1889. The percentage of the total mortality was 10.42, as compared with 10.08 in 1890 and 10.32 in 1889.

From certain infectious causes not mentioned in the foregoing enumeration there were the following numbers of deaths in 1891; those of 1890 are also presented, for the purpose of comparison: —

	Number of Deaths.			Number of Deaths.	
	1890.	**1891.**		**1890.**	**1891.**
Cerebro spinal meningitis,	157	154	Diarrhœa,	618	639
Erysipelas,	174	210	Malarial fevers,	60	62
Puerperal fever,	63	56	Hydrophobia,	17	9
Influenza,	411	546	Glanders,	0	1
Dysentery,	220	234	Malignant pustule,	2	1

Mortality of Urban Population.

An important point in connection with the vital statistics of the State is the rapid increase of its urban as contrasted with the rural population. The former, embracing the population of towns having more than 10,000 inhabitants, has increased from 24 per cent. in 1840 to 61.3 per cent. in 1890. Hence the vital statistics of this portion of the population is constantly becoming of greater importance.

In the following table are presented the numbers of deaths in the cities during the years 1890 and 1891, together with the death rates of each for the census year 1890, and the average death rate of the five census years 1870–90: —

Number.		Deaths, 1890.	Deaths, 1891.	Death Rates.	
				Death Rate, 1890.	Average Death Rate, Five Census Years (1870-90).
1	Boston,	10,126	10,536	22.5	24.1
2	Worcester,	1,495	1,601	17.6	19.7
3	Lowell,	1,960	1,975	25.2	22.5
4	Fall River,	1,705	1,914	22.9	23.4
5	Cambridge,	1,240	1,449	17.7	19.9
6	Lynn,	948	969	17.0	17.8
7	Lawrence,	1,184	1,129	26.5	22.5
8	Springfield,	861	886	19.4	19.3
9	New Bedford,	839	984	20.6	20.9
10	Somerville,	668	782	16.6	18.2
11	Holyoke,	762	713	21.3	23.1
12	Salem,	714	606	23.1	22.1
13	Chelsea,	568	678	20.3	19.7
14	Haverhill,	518	556	18.8	17.8
15	Brockton,	444	410	16.3	16.2
16	Taunton,	493	445	19.4	19.5
17	Gloucester,	424	419	17.4	21.8
18	Newton,	333	349	13.7	13.1
19	Malden,	369	399	16.0	17.0
20	Fitchburg,	323	409	14.6	17.0
21	Waltham,	284	299	15.2	15.3
22	Pittsfield,	345	315	19.9	18.3
23	Quincy,	355	292	21.2	18.7
24	Northampton,	226	268	15.1	17.2
25	Chicopee,	332	321	23.6	20.5
26	Newburyport,	320	304	22.9	21.1
27	Marlborough,	269	202	19.5	17.2
28	Woburn,	222	263	16.4	18.3
29	Medford,	180	149	16.2	-
30	Everett,	175	227	15.8	-
	The 30 cities,	28,682	30,049	20.6	21.4
	The rest of the State,	14,846	15,136	17.6	17.5
	The whole State,	43,528	45,185	19.4	19.7

By the foregoing table it appears that the urban population had a death rate of 20.6 per 1,000 for the year 1890, and 21.4 for the five census years, 1870, '75, '80, '85 and '90; while the rural population had for 1890 a death rate of 17.6, and 17.5 for the five-year average.

Deaths by Violence.

The investigation of this class of deaths is entrusted by law to the medical examiners, and the following summary is compiled from their official returns: —

The whole number of deaths investigated by the medical examiners in 1891 was 1,840. Of this number, 1,362, or 74 per cent., were males, and 457, or 24.8 per cent., were females.

The following table presents a summary of the deaths of this class investigated by the medical examiners for the seven years ending with 1891, these being the years in which official returns were required: —

YEARS.	SEX.						Totals.
	Males.	Per Cent.	Females.	Per Cent.	Unspecified.	Per Cent.	
1885,	973	76.1	286	22.4	19	1.5	1,278
1886,	1,027	74.5	319	23.2	32	2.3	1,378
1887,	1,191	76.5	350	22.5	15	1.0	1,556
1888,	1,261	76.4	373	22.6	17	1.0	1,651
1889,	1,253	75.8	388	23.4	13	0.8	1,654
1890,	1,303	73.5	449	25.3	21	1.2	1,773
1891,	1,362	74.0	457	24.8	21	1.1	1,840
Totals,	8,370	75.2	2,622	23.6	138	1.2	11,130

Homicide. — The deaths by homicide were 60, or 3.26 per cent. of the whole, which was higher than that of any previous year since 1887, when it was 3.34 per cent.

Suicide. — The deaths by suicide were 187, or 10.16 per cent. of the whole number, those of the previous year being 196, or 11.06 per cent.

Accident. — The deaths attributed to accidents were 866, or 47.06 per cent. of the whole number, as compared with 862, or 48.62 per cent., in 1890. Of this number 340 were deaths by railway accidents and by other vehicles for public conveyance. There were by accidental drowning 213 deaths, and by poisons 23 deaths.

The following summary presents the classified statistics of this class of deaths for the seven years of registration : —

Years.	Homicide.		Suicide.		Accident or Negligence.		Natural and Unknown Causes, Including Alcoholism.		Totals.
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.	
1885,	45	3.52	181	14.17	567	44.37	485	37.94	1,278
1886,	47	3.41	157	11.38	678	49.17	496	36.00	1,378
1887,	52	3.34	173	11.12	748	48.07	583	37.47	1,556
1888,	52	3.15	190	11.51	785	47.55	624	37.79	1,651
1889,	51	3.08	199	12.03	792	47.89	612	37.00	1,654
1890,	35	1.97	196	11.05	862	48.62	680	38.36	1,773
1891,	60	3.26	187	10.16	866	47.06	727	39.52	1,840
Totals,	342	3.07	1,283	11.53	5,298	47.60	4,207	37.80	11,130

Water Supply and Sewerage.

Soon after the re-organization of the Board in 1886, the important law giving to the Board advisory powers in regard to public water supplies and systems of sewerage, with authority to conduct experiments, was enacted; and during the past six years the work of the Board in this direction has continued without interruption, and may now be regarded as one of the most important functions of the Board.

In addition to the usual routine examinations of water supplies and of rivers, the present report contains papers presenting a summary of the water supply statistics of the State up to the present date. These show that one hundred and forty-three cities and towns, having a population of nearly two millions, are now furnished with public water supplies, and that only one town having over five thousand inhabitants is without a public supply.

Professor Drown contributes two papers, upon the "Interpretation of water analyses," and upon "The amount of dissolved oxygen in the water of ponds and reservoirs at different depths in winter under the ice;" Mr. Gary N. Calkins furnishes "A study of odors observed in the drinking waters of Massachusetts," and a paper upon the "Seasonal distribution of the microscopic organisms in surface waters." Mr. Allen Hazen, chemist in charge at the Lawrence Experiment Station, contributes a continuation of the report upon the experimental work conducted at the station in 1892, embracing the following important and practical subjects: character of the sew-

age; fats in sewage; fat as a clogging material; experiments with sand clogged by sewage; influence of the amount of sludge in sewage upon the rapidity of clogging; scraping sewage filters; systematic scraping; stratification and the effect of horizontal layers; filtration of sewage containing dye-stuffs; construction of sewage carriers; purification of sewage in winter; on the area of filters to be provided; removal of clogged sand; work of filters for 1892; filling of experimental sewage filters; measurements of sewage applied to filters; operation of experimental sewage filters during 1892. Mr. Hazen's paper upon the "Physical properties of sands and gravels" has a very practical bearing upon the selection of proper soils for the purpose of water and sewage filtration, since very much of the success of this work depends upon the selection of good material for the purpose.

These papers are followed by a description of the sewage fields now in operation at several different places in Massachusetts, and of the results obtained upon these fields in purifying the sewage and producing effluents satisfactory for entering streams in the neighborhood of the fields.

Examination of Artificial Ice.

By a resolve enacted in 1888 (chapter 84, Resolves of 1888), the General Court directed the State Board of Health to investigate the ice supplies of the State, with special reference to "the effect of pollution upon the healthfulness of such ice for domestic use." The result of this investigation was presented in the Twenty-first Annual Report of the Board (1889).

The two succeeding winters after the publication of this report were unusually mild, and there was a consequent scarcity of ice throughout the greater part of the State. As a natural result, there was a demand for other methods of procuring ice than those which were in common use, and were liable to fail in a mild season.

As a matter of convenience, the report authorized by the Legislature of 1893 upon artificial ice is published in this report, although properly belonging to the work of 1893.

Food and Drug Inspection.

At the beginning of the working year, Oct. 1, 1891, the work of the Board in this department was reorganized, and placed under one head, so far as relates to analytical work upon drugs and all

articles of food, excepting milk. That part of the examination of milk which includes the four western counties of the State is still conducted at Amherst. The Board has occupied a laboratory at 994 Washington Street, Boston, during the year 1892, for its analytical work; and as soon as the State House extension is completed, new laboratories in that building will be occupied for the same purpose.

During the past year the work of the Board has been greater than that of any previous year, the whole number of samples examined being 6,199. The number of prosecutions conducted was 135.

The details of this department of the work of the Board, including the reports of the analysts, are presented under the title of "Food and Drug Inspection."

Investigations of Recent Epidemics of Typhoid Fever in Massachusetts.

The State Board of Health is required by statute "to make sanitary investigations and inquiries in respect to the causes of disease, and especially of epidemics." At present no disease is more important for sanitary investigations and inquiries, or more promising, than typhoid fever. During the ten years ending in 1890, according to the official registration reports, the average number of deaths in Massachusetts yearly, from typhoid fever, was 904. The average fatality or lethality from typhoid fever is probably not less than 15 per cent., so that the average morbidity from this disease in this State from 1881 to 1890 may be assumed to have been about 6,000 cases a year. Owing to the peculiarly serious and long-continued character of the disease and the prolonged incapacity of those affected by it, even when it ends in recovery, typhoid fever is one of the diseases most to be dreaded and most damaging to the public health.

Very soon after it was differentiated by pathologists from typhus fever, in the first half of the present century, typhoid fever became recognized by the more acute observers, such as Budd and Murchison, as peculiarly associated with water supplies and sewerage, and as early as 1850 specific epidemics of typhoid fever were attributed to contaminated drinking water. The classical monograph of William Budd, published in 1873, proved beyond all reasonable doubt that typhoid fever proceeds not from mere filth or decomposition (as Murchison and others had supposed), but from previous cases of the same disease. This view of the facts threw a flood of light upon

the causation of the disease, and readily explained why mere filthy conditions so often fail to generate typhoid fever. The downfall of the filth (or pythogenic) theory was completed by the discovery, several years later, by Eberth, of an apparently specific bacillus as the ætiological agent; and the confirmatory work upon Eberth's bacillus by Koch, and especially by Gaffky, between 1881 and 1885, has lent the strongest support to the theory of a specific micro-organism as the sole and sufficient cause of typhoid fever, besides immensely clarifying and simplifying our ideas of its origin and dissemination. It still remains to be rigidly proved that the Eberth bacillus is the one and only factor of the disease, but as the basis of a working hypothesis it has certainly been, already, of the utmost service.

In view of these modern ideas of the ætiology of typhoid fever, much remains to be learned of the precise series of events by which this insidious disease is propagated and disseminated in a community. This fact, and especially the occurrence of extensive epidemics of typhoid fever in the cities of Lowell and Lawrence in the fall and winter of 1890–91, led the Board to undertake and continue a careful series of investigations of these and all other important outbreaks of this disease, which have occurred in Massachusetts since that time. Some of the results of this work have already been published in the report for 1890, in a paper entitled "Typhoid Fever in its Relation to Water Supplies," by Hiram F. Mills, A. M., C. E., member of the Board and chairman of its committee on water supply and sewerage. The special and local investigations of the several epidemics have been made under the general direction of the Board by their biologist, Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, and his assistants, — especially Mr. George V. McLauthlin. The detailed accounts which follow show not only how such inquiries may be successfully conducted, but also demonstrate some of the principal ways in which typhoid fever is disseminated through modern communities. They also indicate the lines along which prevention becomes possible, and thus serve as a contribution to the conservation and promotion of the public health.

It is worthy of special notice that a form of contagion, which, since it is indirect, may be denominated *secondary infection*, appears to play a larger part than might have been anticipated in the dissemination of typhoid fever in Massachusetts. Here, also, the

investigations of the Board strongly confirm those of some of the most eminent inquirers, especially Nathan Smith, Bretonneau, Louis and Budd.

Some of the following investigations have been made at the specific request of the local boards of health of the cities or towns affected, and in every case the local board of health has cheerfully co-operated with, or lent its valuable aid to, the State Board of Health, while the latter was conducting its inquiries.

Registration of Practitioners of Medicine.

Many inquiries are received every year at the office of the State Board of Health, asking information as to the requirements necessary to practise medicine in Massachusetts. These inquiries come from two sources; namely, from the public health officials of other States, and from physicians living in other States and provinces, who signify their intention to practise medicine in Massachusetts. It is sufficient to say, in reply to these inquiries, that at present there are no requirements whatever regulating the practice of medicine in the State of Massachusetts.

Local Nuisances.

A considerable number of communications is received every year at the office of the Board, requesting the Board to abate local nuisances in cities and towns. The statute relating to this subject is quite explicit, and gives no authority whatever to the State Board of Health to remedy ordinary local nuisances. Neither is the Board a board of appeal in such matters. The only appeal provided by the statutes is an appeal to the county commissioners, "who may hear and determine the matter of such appeal, and exercise in such case all the powers which the (local) board might exercise."

The prevention and the regulation of local nuisances is very properly entrusted to the local board of health by the provisions of chapter 80 of the Public Statutes, sections 18 and 20, which provide that the "board of health of a town shall make such regulations as it judges necessary for the public health and safety, respecting nuisances, sources of filth and causes of sickness," and that "the board shall examine into all nuisances, sources of filth and causes of sickness, within its town, or in any vessel within the harbor of such town, that may, in its opinion, be injurious to the health of the

inhabitants, and shall destroy, remove or prevent the same, as the case may require."

Pollution of Ice Supplies.

After a public hearing in 1886 upon the subject of the pollution of ice supplies, the Legislature of that year enacted the following statute : —

[Acts of 1886, Chapter 287.]

Section 1. Upon complaint in writing of not less than twenty-five consumers of ice which is cut, sold, and held for sale from any pond or stream in this Commonwealth, alleging that said ice is impure and injurious to health, the state board of health may appoint a time and place for hearing parties to be affected and give due notice thereof to such parties, and after such hearing said board may make such orders concerning the sale of said ice as in its judgment the public health requires.

Sect. 2. The supreme judicial court in term time or vacation may issue an injunction to enforce such orders of the state board.

Sect. 3. Such orders of the state board of health shall be served upon any person or persons who are or have been selling said impure ice, and any party aggrieved thereby shall have the right of appeal to a jury and be subject to the provisions of sections eighty-eight, eighty-nine and ninety of chapter eighty of the Public Statutes, and the court may render such judgment as to costs as in its discretion may seem just.

Under the provisions of the foregoing act no complaints were made to the State Board of Health until 1892, when certain consumers of the ice furnished by the Swampscott Ice Company, twenty-five in number, petitioned the State Board of Health for a hearing under this act. The hearing was held at the office of the Board, Feb. 2, 1892; and after considering the evidence presented the Board replied that they "had not received evidence to justify them in issuing orders to restrain the sale of this ice."

The Weekly Mortality Reports.

Under this title it has been customary to present each year a summary of the returns which are received at the office of the Board each week from such cities and towns of the State as furnish this desirable information. In turn the Board publishes the results of these returns in the form of a weekly bulletin, which is sent to each city and town in the State. The chief advantages of this system of

returns lies in the fact that it presents a continuous history of the prevalence of infectious diseases throughout the State from week to week for a series of years, and often furnishes valuable assistance in the investigation of local epidemics.

Health of Towns.

The boards of health of the greater part of the cities and many of the towns have furnished the Board with copies of their reports for the year 1892, and from these a digest has been made of the principal points of interest relating to the public health. In 1891 a table was introduced in which were presented the statistics relative to notification of infectious diseases from as many cities and towns as was possible, and this table has been continued in the present report. From a comparison of these returns with those of mortality it is possible to arrive at an approximate estimate of the fatality of each one of the diseases in question.

Offensive Trades.

One petition only was made to the Board during the year, under the provisions of the act relating to offensive trades. This petition was signed by citizens of Salem, and had reference to an establishment located in the south part of Salem and east of the Boston & Maine Railroad, and used as a tannery and glue factory. A hearing was given to the petitioners at the office of the Board Jan. 5, 1892, with reference to this establishment, but no action was taken, since it was determined that the parties alleged in the petition to be the proprietors of the glue factory were not the proprietors of the same. It was therefore decided that a hearing should be held upon a new petition.

Routine Work of the Board.

During the year ending Sept. 30, 1892, the Board held fourteen regular meetings, besides meetings of standing committees. Public hearings were also granted upon the following matters, under the provisions of chapter 375 of the Acts of 1888, and of other statutes: —

Revere sewerage and sewage disposal,	Nov. 17, 1891.
Revere sewerage and sewage disposal,	Jan. 5, 1892.
Relative to the establishment of Poor Brothers at Salem, under the offensive trade act,	Jan. 5, 1892.

Relative to the pollution of the ice supply of the Swampscott Ice Company,	Feb. 2, 1892.
Relative to the sewage disposal of Palmer,	June 2, 1892.

The statistics of the work of the Board in the matter of food and drug inspection have been published by the Board monthly in the same sheet with the weekly bulletin of mortality statistics issued by the Board.

No small part of the work of the office at the present time consists in the giving of advice to local authorities upon such subjects as are presented. Frequent visits are also made to different cities and towns by officers of the Board, for the purpose of sanitary investigation and conference with local boards of health upon sanitary matters.

The following table presents certain statistical data relative to the ro tine work of the Board : —

Statistical Table for the Year ending Sept. 30, 1892.

Whole number of samples of foods and drugs examined during the year,		6,199
Samples of milk examined (included in the foregoing),		3,271
Whole number examined since beginning of work in 1883,		47,164
Whole number of samples of milk examined since beginning of work in 1883,		24,003
Number of warning notices issued relative to adulteration during the year,		405
Number of prosecutions against offenders during the year,		135
Number of convictions during the year,		123
Amount of fines secured during the year,		$3,661.70
Force employed at Boston, for food and drug inspection, chemists and assistants,	2	
At Amherst,	1	
	—	3
Inspectors,		3
Total,		6

Under the Provisions of the Act to protect the Purity of Inland Waters.

[This table applies to the calendar year ending Dec. 31, 1892.]

Applications for advice from cities, towns and others : —	
Relating to water supply,	37
Relating to sewerage and drainage,	19
Total,	56

Number of samples of water examined chemically and microscopically at Massachusetts Institute of Technology,	1,455
Number of samples of sewage and water examined chemically and bacteriologically at Lawrence Experiment Station,	2,021
Number of samples of sand examined at the Lawrence Experiment Station,	282
Additional samples examined bacteriologically at Lawrence Experiment Station,	6,124
Total number of samples examined,	9,882

Force employed at 13 Beacon Street: —		
Chief engineer,	1	
Assistant engineers,	2	
Stenographer and clerk,	1	
	—	4
At Massachusetts Institute of Technology: —		
Chief chemist,	1	
Assistant chemists,	4	
Chief biologist,	1	
Assistant biologists,	2	
	—	8
At Lawrence Experiment Station: —		
Chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	5	
	—	9
Total ordinary force,		21

The number of applications received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows: —

1886,	8
1887,	22
1888,	28
1889,	38
1890,	23
1891,	53
1892,	56
Total,	228

Expenditures.

The expenses of the Board during the year ending Sept. 30, 1892, under the three appropriations for general expenses, food and drug inspection, and water supply and sewerage work, were as follows: —

General Expenses.

Salaries,	$5,081 96
Printing,	1,103 96
Travelling,	1,079 76
Special investigations,	858 11
Postage,	40 50
Books, subscriptions and binding,	182 71
Express,	196 32
Stationery,	129 48
Telephone,	122 80
Type-writer and library supplies,	6 50
Office incidentals,	81 34
Type-writing and stenographic experts,	125 00
Telegrams,	9 25
Apparatus,	42 03
Experts and legal advice,	86 00
Total,	$9,145 72

Food and Drug Inspection.

Salaries of chemists,	$4,130 00
Salaries of inspectors,	3,858 34
Travelling expenses and purchase of samples,	1,982 95
Legal services,	35 00
Apparatus,	764 61
Printing,	3 45
Rent of laboratory,	300 00
Furniture and fittings,	42 95
Chemical analysis (disputed samples),	63 00
Total,	$11,180 30

Water Supply and Sewerage.

Salaries,	$22,451 49
Experiment Station at Lawrence (rent),	150 00
Experiment Station at Lawrence (use of tools and office),	396 65
Travelling,	538 20

Rent at Massachusetts Institute of Technology,	$900 00
Express,	485 18
Apparatus and materials,	1,761 12
Printing,	79 28
Stationery and drawing utensils,	70 98
Maps and blue prints,	36 95
Book binding and subscriptions,	107 62
Postage,	16 40
Telegrams and messages,	5 77
Total,	$26,699 64

Recommendations.

The following recommendations were made to the Legislature in the Report of the Board made Jan. 10, 1893. (Senate Document 4, 1893.)

The Board recommends the continuance of the investigations already commenced and those indicated as desirable in the foregoing report.

For these purposes, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best method of assuring the purity of intended or existing water supplies, and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of $27,000 will be required.

The Legislature adopted the suggestion of the Board, and made the appropriation named in the foregoing recommendation.

H. P. WALCOTT,
J. W. HASTINGS,
H. F. MILLS,
F. W. DRAPER,
MORRIS SCHAFF,
E. U. JONES,
G. C. TOBEY,
State Board of Health.

WATER SUPPLY

AND

SEWERAGE.

ADVICE TO CITIES AND TOWNS.

WATER SUPPLY AND SEWERAGE.*

[Report required by the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage."]

The following report contains a summary of the work of the State Board of Health during the year 1892, under the provisions of chapter 375 of the Acts of 1888. It embraces the substance of the replies made by the Board to those cities, towns, corporations and individuals which have applied to the Board for its advice relative to systems of water supply, drainage and sewerage, under the requirements of the act, together with a brief statement of the work done at the experiment station in Lawrence.

The drought which prevailed during the summer and autumn of 1891 was followed by an unusually small flow of the streams during the spring of 1892, so that the total flow for the year ending May 31, 1892, was lower than for nine years, and only sixty-nine per cent. of the average for a long series of years. The year was the third in the order of dryness during the past eighteen years. The dryer years were those ending May 31, 1880 and 1883, when the flow was respectively sixty and fifty-four per cent. of the average.

Although the year ending May 31, 1892, has been so dry, the drought has affected very differently different classes of water supplies. Those which are taken from large drainage areas with comparatively little storage have not been particularly troubled by the drought, while those that are taken from large ponds with small drainage areas have been very much affected on account of the low flow during the winter and spring of 1892, and the ponds have been drawn to a lower point than ever before, thereby indicating the urgent need

* The first 71 pages of this report were contained in a report made to the Legislature Jan. 10, 1893. A portion of the report then made, relating to the work done at the Lawrence Experiment Station, is not reproduced, because a more complete account of the work done at this place will be found in a subsequent part of this volume.

of an additional water supply. This is particularly the case at Spot Pond, which supplies water for Malden, Medford and Melrose; at Wenham Lake, which supplies Beverly and Salem; and at Lake Williams, which supplies water for Marlborough.

The fact that several places which are short of water at the present time are located within the Metropolitan district again calls attention to the difficulty of obtaining a permanent and satisfactory supply for such places by their independent action.

In the early part of the work of the State Board of Health under the provisions of the act relating to water supply and sewerage, it had occasion to examine into the sources of water supply of the cities and towns surrounding Boston, and found that, while some of the suburban communities had a water supply which was satisfactory both in regard to quantity and quality, the greater number derived their supply from sources which either received much polluting matter or would prove inadequate in very dry years, such as have occurred in the past. In endeavoring to find sources which could be used as substitutes for those now used, or to supplement them where the quality of the water from the present source was satisfactory but the quantity insufficient, it was found that new sources which would be at all permanent were at such a great distance from the communities that the independent action of such communities would be attended with great expense, and that it would be necessary before long to have concerted action to supply the needs of many suburban communities. The general subject of the future water supply of the Metropolitan district is engaging the earnest attention of the Board.

During the year 1892 the regular chemical and microscopical examination of the water supplies of many of the towns has been continued, and a large number of additional examinations of waters has been made in connection with advice to cities and towns regarding new supplies. There have also been made many analyses of water in connection with investigations into the causes of epidemics of typhoid fever. The total number of waters examined has been 1,455, which may be classified as follows: —

From new reservoirs,	52	
From open and covered reservoirs used for storage of ground water,	24	
Special investigations of regular water supplies affected by tastes, odors, etc.,	120	
From ponds and storage reservoirs and their inlets,	432	
From ground water supplies,	263	
From streams and miscellaneous sources,	86	
Total from regular water supplies,		977
In connection with investigations of new sources of water supply,	150	
With reference to pollution of streams,	159	
With reference to sewage purification at Framingham, Marlborough and Gardner,	97	
Spring waters,	20	
In connection with study of epidemics,	15	
Miscellaneous,	37	
		478
Total,		1,455

In addition to these sanitary analyses of waters there have been made, also, in a considerable number of waters, the analyses of the mineral constituents, which it is hoped may throw some light on the occurrence of certain organisms in surface waters, and also indicate the presence of sewage pollution.

There have been made many analyses of the sewage and effluents from the sewage fields at Framingham, Gardner and Marlborough, which show the efficiency of these systems of sewage purification by intermittent filtration. A considerable number of analyses of the water of the tidal portion of Charles River has been made at different conditions of the tide, to determine the movement of sewage in the river.

In previous reports mention has been made of the separation of oxide of iron and *Crenothrix* in imperfectly filtered water, whereby the water is rendered unfit for many domestic uses. This growth of *Crenothrix* and separation of iron is sometimes accompanied by a disagreeable odor and evidences of decomposition. During the latter half of the year 1892 the amount of iron has been determined in all the waters examined in the laboratory. It has been found that the amount of metallic iron in the waters of rivers, ponds

and reservoirs very rarely amounts to 0.1 part per 100,000, and is generally below 0.05 part. Even when present to the amount of 0.1 part, there is no separation of iron in surface waters on standing, for the iron is held in solution by the organic matter present in the water. The case is very different with ground waters, which contain, as a rule, no organic matter. In these waters the iron is usually present in the form of protoxide, which on oxidation by exposure to the air is deposited in the form of a rusty precipitate. The minimum amount of iron which will usually cause a perceptible separation of iron oxide (which appears first as a milkiness in water before the oxide settles to the bottom) may be said to be approximately 0.05 part per 100,000. The presence of 0.1 part of iron causes quite a marked precipitation.

A considerable number of wells which have been sunk in different parts of the State, in the search for new water supplies, has proved to be entirely unfit for general use, owing to the presence of iron, which in some cases has been as high as 1.7 parts per 100,000.

In some cases the origin of this iron has been apparently connected with swamps in the near proximity to the wells, and there is evidence that filter galleries near the banks of ponds or streams may, in the course of time, as the filtering material becomes impregnated with organic substances and iron, yield water which contains iron in solution in sufficient amount to render it objectionable for general use.

In Provincetown, on Cape Cod, where the water in test wells showed the presence of considerable iron, we have the unusual condition of a ground water containing both iron and organic matter.

In cases where there is no other water available for a public supply than a ground water with excessive iron, resort must be had to some system which will remove the iron by oxidation, with subsequent sedimentation or filtration. This subject, which is one of great importance, is still under investigation.

In the biological examination of the waters there has been much study devoted to the seasonal distribution of the different groups of organisms, and to attempts to connect the

various odors met with in surface waters with distinct organisms. The study of *Uroglena*, the organism described at considerable length in the report of 1891 (page 647), has been continued with especial reference to its methods of reproduction. This organism, which is more widely distributed in ponds and reservoirs than was formerly supposed, is the cause of great annoyance by reason of its very disagreeable oily odor.

A condensed summary of the work done at the Lawrence Experiment Station is also presented. Additional information is given in regard to continuous lines of work already begun, together with the results of new investigations upon the following points: the effect of stratification of the filtering material upon sewage purification, the filtration of sewage highly colored with dye stuffs, further experiments upon the efficiency of filtration in removing disease germs from water, the effect of scraping the surface of filters, the relation of the size of sand grains and the depth of filters to the frequency of scraping, the effect of the rate of filtration upon the quantity of water filtered between the scrapings, the effect of the method of applying water on the frequency of scraping, the relative percentages of bacteria removed by filtration under different conditions, the effect of the size of sand grains on the efficiency of filtration, the effect of the depth of material on efficiency of filtration, the effect of the rate of filtration on the removal of bacteria, the distribution of bacteria within the filter, and the mechanical examination of proposed filtering materials.

ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, the Board is required "from time to time to *consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities,*

towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided*, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. *All such authorities, corporations, firms and individuals are hereby required to give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage; and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of the said Board thereon.*"

During the year 1892 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Replies were made during the year to applications received from the following sources for advice relative to water supply: Ashburnham, Attleborough, Canton, Chicopee, The Chicopee Water Company, Clinton, Hyde Park, Ipswich, Kingston, Lawrence (two replies), Lowell (two replies), Malden, Marlborough, Medfield, The Medfield Insane Asylum, Medway, Millbury, Millis, Milton, Nantucket, Newburyport, North Brookfield, Pittsfield, Provincetown (two replies), South Hadley, Stoneham, Stoughton, Uxbridge, Waltham, West Boylston, Williamstown, Winchendon and Winthrop.

Replies relating to sewerage and sewage disposal were made in response to applications from the following sources: Brockton, Brookfield, Hull, Lenox, The Massachusetts Hospital for Dipsomaniacs and Inebriates (three replies), The Medfield Insane Asylum, Natick, Revere, Shelburne, Southbridge (two replies), Wakefield (two replies), Westborough, Westfield and Winthrop (two replies).

Applications from the following cities and towns were also received during 1892, but action has not yet been taken upon them, either in consequence of special circumstances which have required delay, or because they were received too late in December for action in 1892: Arlington, Brockton, Melrose, North Andover, Palmer, Pittsfield, Scituate and Westborough.

A reply was also made to the board of health of Millbury in answer to certain inquiries relative to the pollution of the Blackstone River.

Water Supply.

The following is the substance of the action of the Board in reply to applications for its advice relative to water supplies: —

Ashburnham. The Naukeag Water Company of Ashburnham applied to the Board (March 28, 1892) for its advice relative to a proposed additional supply of water for that town, and the Board replied to the application as follows: —

April 6, 1892.

The State Board of Health has considered your application, dated March 28, 1892, with regard to a proposed additional water supply in the town of Ashburnham, to be taken from the watershed which now supplies the central village and from adjacent territory.

The leakage from the reservoir at the present time permits a large amount of water to escape under the dam. This leakage should be prevented as far as practicable. It is probable, however, that a comparatively large amount of water will still flow out of the ground below the dam, so that the largest additional supply can be obtained by intercepting this water. Ditches extending out from both sides of the reservoir to intercept and divert into the reservoir the water which now flows past it on either side will also add to the supply. From these additional sources a valuable additional supply can be obtained, but it is not feasible to tell in any way except by actual trial whether these additions will increase the quantity of water to such an extent as to provide a full supply for the village in a very dry year.

The water now supplied to the village is of good quality, and will probably continue to be of satisfactory quality after the additions here mentioned are made.

Attleborough. In the last report of the Board to the Legislature (Senate Document, No. 4, 1892) it was stated that the Fire District No. 1 of Attleborough applied to the State Board for its advice upon the desirability of certain proposed sources of water supply. After carefully considering the subject, the Board advised the applicants to make a further examination near the Seven-mile River, at the same time affirming that, "if it should be found that the coarse and porous material at this place extends over a large area and to a considerable depth, this source will be the best of any investigated and probably the best source available for the water supply of Attleborough." This examination was made according to the advice of the Board, and on April 26 the result was communicated to the Board, with a request for its opinion on the desirability of selecting this source. The Board replied as follows: —

May 5, 1892.

The tests which you have made give very favorable results as to the depth and extent of the porous material, and it is probable that a sufficient supply for double the present population of the town can be obtained from the ground at this place. If, however, the quantity to be obtained in a very dry year should prove to be less than is now anticipated, the proposed location is a favorable one from which to extend works for obtaining a supplementary supply from the ground, or, if necessary, from surface water sources.

Canton. The water commissioners of Canton having applied to the Board for its advice as to an additional water supply (April 16, 1892), the Board made the following reply: —

May 5, 1892.

The State Board of Health has considered your application, dated April 16, 1892, with regard to an additional water supply to be taken from a well near the Henry Springs, so called.

An analysis of a sample of water collected from the flowing well in this vicinity shows that the water is of excellent quality. A measurement of the water flowing from the springs and an examination of the surrounding territory indicate that this source will not furnish a sufficient additional supply to warrant its adoption, unless a further quantity of water, to be used in connection with it, can be obtained from some other source or sources. In addition to the Henry Springs what is most needed

is further storage capacity to maintain the supply during the dryer portions of the year.

One way of obtaining this storage capacity would be to make available for use some of the water now stored in the ground in the valley of Beaver Brook below the Henry Springs. In order to make this ground water available it would be necessary to dig or drive wells and connect them with the proposed main pipe leading from the Henry Springs to the present well. This pipe should have a continuous fall, and be laid at a considerable depth below the ground-water level in those portions of the route where the ground is of such a character that an additional supply may be obtained from it. Additional ground water might also be obtained by means of a branch pipe and wells in the valley of Dead Meadow Brook.

Another way of obtaining a supply during the dryer portions of the year would be to increase the storage capacity of York Pond, and extend to it the pipe which takes the water from the Henry Springs. The water of this pond is of excellent quality for a surface water, but would not be quite as satisfactory as a good ground water.

It seems probable that a sufficient supply of good water can be obtained from the valley of Beaver Brook at a less cost than by going to any entirely new source. The best method of obtaining the supply, however, cannot be determined without more extended investigations than it is feasible for this Board to make. The town is therefore advised to have further investigations and estimates made, to determine whether it is feasible to obtain a sufficient supply of ground water by the method above indicated.

THE CHICOPEE WATER COMPANY. The Chicopee Water Company applied to the Board (Feb. 3, 1892) for its advice as to taking the waters of certain springs and brooks not yet taken by them, but within the limits of the territory described in their act of incorporation. The Board replied to the company March 1, 1892, approving the proposed additional sources for additional supply.

CHICOPEE. The city of Chicopee applied to the Board (May 23, 1892) for its advice relative to certain brooks north of the Chicopee River as sources of water supply. To this application the Board replied as follows: —

JUNE 2, 1892.

The brooks mentioned in your application are Cooley and Fuller brooks, which enter the Chicopee River from the north within the

city limits, and Morton Brook, a tributary of Cooley Brook, which enters it from the west. Another brook, known as School-house Brook, which lies just west of Cooley Brook and wholly within the city limits, was also examined.

Analyses of the water of these streams and an examination of the territory from which they derive their supply show that they should be ranked as regards quality in the following order: —

1. Morton Brook.
2. School-house Brook.
3. Cooley Brook.
4. Fuller Brook.

The waters of Morton and School-house brooks are very nearly colorless, and are shown by analysis to contain but a very small amount of organic matter, and in all respects they rank very high as drinking waters. These streams, however, are too small to furnish in a dry time as much water as will be required for the supply of the whole city. They are, however, valuable as auxiliary sources, because during portions of the year they will furnish a full supply, and during other portions of the year, by taking as much water as possible from them, the quality of the water supplied to the city will be better than if taken wholly from either of the other sources.

There is some doubt as to whether School-house Brook can be made available in connection with the other sources at a reasonable expense; but the Board is of opinion that it would be well for the city to obtain the necessary authority to take water from this source, and to utilize it if it should be found desirable when the final plans are made.

The water of Cooley Brook was analyzed on two occasions, once on Aug. 17, 1889, and again on May 26, 1892. On both of these occasions it had considerable color, although considerably more by the recent examination than by the previous one. Both of these samples were taken only a few days after heavy rains, which, by causing an overflow of water from swamps, generally increases the color. The average for the year would probably be less than on these occasions. The amount of organic matter is somewhat higher than in either Morton or School-house Brook, but is not excessive. The water comes from a territory which is almost wholly free from artificial pollution, and from a health stand-point would rank well as a drinking water. This brook drains a much larger area than Morton or School-house Brook, and, as the greater part of this area is an extensive sandy plain, which would tend to equalize the flow of the brook throughout the year, the summer flow would be unusually large in proportion to the size of the drainage area.

It is not feasible to tell just how much these sources will furnish by their natural flow in a very dry season, but there is scarcely any doubt that they will furnish more water than is required for the village of Chicopee Falls, which it is understood is to be supplied first; and it is not improbable that the whole present population of the city might be supplied from these sources without providing any more storage capacity than is needed to prevent the water from running to waste at night during the dryest portions of the year. If Chicopee Falls only is supplied in the beginning from these sources, it would be advisable to provide means for measuring the flow during the dryer portions of the year; and with the information derived from such measurements it would be feasible to determine whether it would be necessary to provide storage reservoirs on Cooley Brook, or to obtain a supplementary supply from some other source, in order to provide enough water for the whole city.

Fuller Brook is a less desirable source as regards quality than either of the others, as its water has a somewhat higher color, and contains more organic matter. There is also a larger population upon its water-shed, and there are several small mills upon it. The Board does not, therefore, advise taking the water from this brook if a sufficient supply can be obtained from the other streams. It may be advisable, however, to obtain authority to take water from this stream within the limits of the city, as it is near the other sources and may be of value as a supplementary supply in cases of emergency, particularly in the future, when the consumption of water is increased by the growth of the city.

CLINTON. The water commissioners of Clinton applied to the State Board of Health (Dec. 1, 1891) for advice relative to taking Waushacum Pond in Sterling as an additional source of water supply. To this application the Board replied as follows: —

JAN. 26, 1892.

From the examinations and the information which you have submitted, the Board is of opinion that a further supply of water is needed for your town.

The additional quantity of water to supply the town for many years can be obtained either from Heywood's Brook, which the town is authorized to take, by constructing a large reservoir upon it, or from East Waushacum Pond.

Heywood's Pond has now upon it a large mill-pond, the upper end of which is very shallow; and above the pond are several

swampy areas. On account of these swampy areas and the vegetable growths in the pond the water now has a high color and is not of satisfactory quality for water-supply purposes, although it has the advantage that it is practically free from sewage pollution. If, however, a deeper reservoir should be made at this place by flowing the water to a greater height, and this reservoir properly prepared for the reception of water by the removal of all soil, peat and vegetable matter from its bottom and sides, the character of the water would be greatly improved and would probably be satisfactory for water-supply purposes; although it could hardly be expected to have the high degree of excellence which characterizes the water of East Waushacum Pond.

The development of Heywood's Brook has been referred to here because it presents one method by which an additional supply of water of good quality may be obtained for the town, and it has one advantage over East Waushacum Pond, — that the water would flow by gravity to the highest parts of Clinton, while a gravity supply from the pond will only supply the lower portions of the town.

The relative cost of obtaining an additional supply from the two sources mentioned cannot be determined by the Board from the information now before it.

The quality of the water of East Waushacum Pond is, as before indicated, excellent; and, in connection with the present sources as now developed, it will furnish a sufficient quantity of water to supply your town for many years. As this pond is in the town of Sterling, and may be the most appropriate source of supply for this town or some part thereof in the future, the Board is of opinion that, if you obtain rights to take water from this pond, they should not be such as to prevent the town of Sterling from also obtaining a supply from it.

Hyde Park. The Hyde Park Water Company supplies water to the inhabitants of Hyde Park and Milton from a large number of driven wells east of the Neponset River. In the summer of 1892, use was also made of the water of a large well near the starch factory, and quite near the Neponset River. The Board informed the water company that the "analysis of the water from the well at the starch factory indicated that it was to a large extent imperfectly filtered river water," and that "the water from this source should not be used."

On August 31 the Board received a communication from

the school committee of Hyde Park asking the opinion of the Board as to whether the school committee could "safely supply the children of the schools with this water for drinking purposes at the opening of the schools," to which the Board replied as follows: —

SEPT. 1, 1892.

We have made examinations of the sources from which the Hyde Park Water Company takes its supply. These examinations were made on July 27 and Aug. 4, 1892, and at that time the water was derived from two sources, one the driven wells which had been in use for several years, and the other a large well near the starch factory, which was first used this season.

The analyses of the water from the well near the starch factory show that it derives its supply from the Neponset River, which is a much polluted stream, and that the water is not well purified by filtering through the ground. The Board is therefore of opinion that the use of water from this well is liable to endanger the public health, and that until this source is abandoned it would not be safe to supply the children of your schools with the water furnished by the water company for drinking purposes.

The above opinion as to the quality of this water was communicated to the Hyde Park Water Company on August 3 and 5.

IPSWICH. The selectmen of Ipswich applied to the Board for its advice (July 21, 1892) relative to the propriety of taking certain springs in Ipswich as a source of water supply for the town, to which the Board replied as follows: —

AUG. 5, 1892.

The State Board of Health has considered your application, dated July 21, 1892, with regard to a proposed water supply for the town, to be taken from springs about one mile south of the village on the farm of Augustine Stone, and has caused examinations to be made by its engineer of the springs and the territory from which they derive their supply. From the information thus obtained the Board is of opinion that this source cannot be made to furnish a sufficient supply of water for a long enough time in the future to warrant its adoption.

The Board would repeat its former advice, that the ground near the Ipswich River not far above the town be examined as a source for a water supply.

KINGSTON. The water commissioners of Kingston applied to the Board (Aug. 1, 1892) for its advice relative to the

quality of their existing water supply, and as to the propriety of taking the water of Stetson's Pond as an additional source of supply. The Board replied as follows: —

SEPT. 1, 1892.

In compliance with your request, dated Aug. 1, 1892, asking for an examination of the water of the filter gallery from which a part of the present supply is derived, and also for an examination of the water of Stetson's Pond, with a view to determining whether it is a suitable source from which to obtain a temporary additional supply, the Board has caused the desired examinations to be made.

The chemical analysis of the water from the filter gallery is about the same as other analyses of water from your well and filter gallery made in previous years. The microscopical examination, however, shows the presence of *Crenothrix* and *Zoöglœa* in moderate numbers. These organisms are commonly found in filter galleries located very near streams when the level of water in them is kept so low that a part of the water filters from the streams. It is not known that they are detrimental to health, although they render the water less satisfactory for domestic use.

The chemical analysis of the sample from Stetson's Pond shows that the water is soft and colorless, but when shaken in a bottle it had a distinctly vegetable odor, caused by the microscopical organisms in it. The most abundant organism shown by the microscopical examination is *Anabœna*, a blue-green Alga, which in some cases has made water very disagreeable in taste and odor. In this case, as in the other, however, there is no reason to think that the water would be detrimental to health.

If all the soil and vegetable matter were removed from the bottom and sides of this pond and the shallow portions were deepened, it is probable that the water would be so far improved as to be satisfactory; but it would be advisable, before entering upon any extended improvements with a view to using this source permanently, to determine whether it will furnish enough water to meet the present and future requirements of the town.

The results of the chemical and microscopical examinations are enclosed.

LAWRENCE. The water board of Lawrence applied to the State Board of Health (March 1, 1892), asking for information relative to the question of the mechanical filtration of the water of the Merrimack River, and as to what method the State Board would advise for the purpose. The Board replied as follows: —

MARCH 9, 1892.

The State Board of Health has made examinations of water from several of the mechanical filters used in the country, and has found none in which all of the bacteria had been removed, hence it is unable at present to advise you that any of the rapid mechanical filters now used in the country will purify the Merrimack River water sufficiently to insure exemption from disease being communicated through the water when typhoid fever or cholera or other diarrhœal diseases may exist at Lowell.

The Board has found that typhoid fever bacteria may be entirely removed by a process of slow intermittent filtration at the rate of 400,000 gallons per acre per day. It has not yet succeeded in entirely excluding them with the rate of 1,000,000 gallons per acre per day, but can probably attain the result with some rate higher than 400,000 gallons. With 400,000 gallons per acre per day Lawrence would require a filtering area of about eight acres, made of such sand and loam as are found in the vicinity.

At a later date (May 7) the water board applied to the Board of Health for its advice relative to the operation of filtration through sand, and as to the best place for the location of such a filter. To this application the Board made the following reply: —

JUNE 5, 1892.

The State Board of Health has received your communication of May 7, 1892, and desires to give to the Lawrence water board any information it may have that will aid you in determining what should be done to provide a wholesome water supply for the city of Lawrence.

The experiment station of this Board will be open to the inspection of the Lawrence water board at any time, and, upon notification, this Board will provide that your board shall be met either by Mr. Mills (under whose direction the experiments are being made), or in his absence the Board will arrange that Mr. Hazen, who has charge of the chemical department, shall show you the construction of the filters and the results of chemical examination of the filtered and unfiltered waters, and that Mr. Fuller, who has charge of the biological department, shall show you the methods of bacterial examination, and the results obtained in removing bacteria and typhoid fever germs from water by the several filters.

It is to be understood, however, that the Board of Health, while free to show you everything it is doing which is of interest to the work you have in hand, has not authorized its employees to give you any advice in regard to your work. It is necessary that such

advice should be limited to the definite action of the Board, given in writing, after the subject has been fully investigated in all its bearings. Since the communication of this Board sent to you March 9, 1892, very interesting and important results have been obtained at the experiment station. Upon filters of sand five feet deep, devised by Mr. Mills, hundreds of millions of the germs of typhoid fever have been applied to the surface, with water flowing through at the rate of one and a half million gallons per acre daily; but, though examined with the greatest care, none of the germs were found in the water leaving the filter.

To supply the city of Lawrence with water through such filters would require an area of about three acres; that is, there would be required a shallow reservoir about six feet deep, having an area of three acres, situated just above the level of the entrance to the present reservoir. This reservoir should have suitable drain pipes in the bottom, and be filled to the depth of five feet with gravel and sand in layers of the proper fineness, such as can be found within the limits of the city.

These results have been obtained upon filters carefully prepared in the laboratory, which are of forms believed to be adapted to use on a large scale; but such arrangements must be conducted with care, and used under intelligent supervision, in order to obtain as satisfactory results. Among other things, the water should be freed from sediment brought down by the freshets before applying it to these filters. To accomplish this, a filter of coarse sand should be provided at the river bank. At first this could be made adjacent to the old filter gallery, and afterward be extended along the river bank, with large underdrains leading to the present filter gallery or to the pump well. Upon the surface of this filter the fine sand brought down the river in time of freshets, and nearly all suspended matter, would be deposited, and should be removed so frequently that the effective area of the filter would not be impaired.

The Board of Health would advise that, in its judgment, a marked decrease in the death rate from typhoid fever can be made simply by the construction and proper use of the filter referred to, at the river bank. This filter would not remove the impurities of the river water to the full extent that is desirable; but much benefit can be derived from such a filter made without great expense in connection with the present filter gallery; and, as it would be an essential part of the filters required for the complete purification of the water, the Board of Health would advise its immediate construction for use, while the more complete system is being constructed.

The pressing need of this preliminary work is shown by the fact that in the first five months of the present year the death rate from typhoid fever in Lawrence has been seven times that of Boston; or, if Lawrence had had in these five months the same number of deaths from typhoid fever for each thousand of inhabitants as Boston, there would have been fifteen less deaths than are recorded.

In the judgment of this Board, nearly all of such excessive number of deaths can be avoided by filters at the river bank; and, while the experience of the Board gives it confidence that a system of filters such as are indicated in the earlier part of this communication would satisfactorily purify the water for the city, it may be shown by the preliminary work advised that this result may be accomplished with a sufficient area at the river bank.

If you shall undertake to purify your water by filtration, under the advice of the State Board of Health, it is essential to success that the filters be properly constructed, that they be used in a proper manner, and that they have daily the necessary intelligent care. To aid you in accomplishing these essentials this Board will co-operate with you as long as you may follow its advice, and will instruct its engineer to advise you in regard to the method of construction and material to be used, and will advise your superintendent from time to time of the best method of using and taking care of the filter beds.

Lowell. The Lowell water board applied to the State Board of Health (Dec. 14, 1892), requesting the aid and co-operation of the latter "in determining upon some better source than that of the present, or in finding some means of purifying the present city supply." The Board replied as follows: —

Feb. 4, 1892.

This Board will cordially co-operate with you, and give you any aid in its power in the method prescribed by the statute. This method requires that you shall first present to this Board outlines of your proposed plans in relation to an improved water supply.

There appears to be reason in following the method prescribed by the statute, in that this Board, being required to judge and advise you in regard to all of the plans which you may in your investigations think best to submit for its consideration, should not at the beginning of the investigations formulate plans which might interfere with its free and full consideration of any plans which you may hereafter present.

Upon receiving from your board such plan or plans as your

investigations indicate to you to be most likely to serve your purpose, this Board will give to them careful consideration and advise you as to further action. In the mean time the observations made by the officers of the Board upon sources of water supply that may be available for your city are open to your inspection.

On May 4, 1892, the Lowell water board again applied to the State Board of Health, asking its co-operation and advice relative to the introduction of a system of water supply from driven wells. To this request the Board, after careful investigation of the subject, answered as follows: —

SEPT. 3, 1892.

Your application of May 4, 1892, asking the advice of the State Board of Health with regard to obtaining a water supply for Lowell by means of a system of driven wells, has been carefully considered, and the Board, having caused extended examinations to be made by its engineer, in co-operation with the city engineer of Lowell, herewith presents its reply.

The localities for obtaining a supply of this kind, to which attention has been called by your engineer, are along the northerly bank of the Merrimack River near the Pawtucket boulevard, where test wells have already been driven, and on the northerly bank of the river, near the mouth of Beaver Brook.

The average consumption of water in Lowell, as given in your report for 1891, was nearly 6,000,000 gallons per day, while six years before the consumption was about 3,500,000 gallons, making the average yearly increase in the amount of water consumed about 400,000 gallons per day. If the consumption continues to increase at this rate, an average supply of 8,000,000 gallons daily will be required in 1896. It will therefore be seen that a new supply would be required to furnish, almost in the beginning, 8,000,000 gallons per day, and in the beginning or by future extensions it should be capable of furnishing a much larger quantity.

The history of the present filter gallery has an important bearing upon the question of obtaining a supply by means of driven wells from the territory near the boulevard. The filter gallery was originally constructed with a view to obtaining water by filtration from the river during the portion of the year when the river water was objectionable on account of its turbidity. After the filter gallery was constructed and put in use, in 1873, its water was examined chemically, and the temperature was noted. It was then

found that the character of this water by chemical analysis was very different from that of the river water, and that the water in the gallery was very much colder during the warm weather, and varied scarcely any with the season of the year. These facts led to the conclusion that the filter gallery derived its supply from the land side, and not from the river. More recent examinations by the State Board of Health at other places have shown that the filtration of water through the ground can produce a sufficient change in its character to account for the differences then noticed, and it has also been found that under some conditions water which has filtered from a pond to a filter gallery has a nearly uniform temperature throughout the year. The facts observed in 1873, which led to the conclusion that the water did not come from the river, would not, therefore, be interpreted in the same way at the present time.

By collecting the analyses of water from the Lowell filter gallery from 1873 up to the present time it was found that there has been a very great change in the character of the water, which can only be accounted for by the supposition that the greater part of the water filters from the river, as no such change would have occurred had all the water come from the land side. Not only do these analyses show that the water comes from the river, but they also show that the organic matter of the river water has been stored in the ground during the many years that the filter gallery has been in operation, until the efficiency of the ground as a filter has been seriously impaired. Decomposition is now going on in the ground, where free oxygen is absent, thereby producing free ammonia, and reducing the iron contained in the ground to such a condition that it can be dissolved by water and carried into the filter gallery. When the water is again exposed to the air, oxidation takes place, producing minute particles of iron rust, which give the water color and render it turbid. The change in the character of the water since 1873 is indicated by the following abstract from the analyses: —

Date.	By Whom Analyzed.	Free Ammonia.	Chlorine.
Sept., 1873,	W. R. Nichols,	.0013	.22
June, 1874,	W. R. Nichols,	.0063	.26
July, 1885,	S. Cabot,	.0140	.41
June, 1892,	State Board of Health,	.0456	.29
July, 1892,	State Board of Health,	.0530	.26

The recent analyses show that the water from the upper end of the filter gallery, after standing for a time, has a decided turbidity, a heavy red sediment and considerable color. It also has an offensive odor when cold, which disappears on heating. The free ammonia is extremely high, occasioned, as before stated, by the contact of the water with decomposing organic matter in its passage through the ground from the river to the filter gallery. The amount of organic matter remaining in the water when it reaches the filter gallery is not very large, although somewhat greater than in 1873. The amount of chlorine and nitrates is comparatively small, and the former has not increased materially since 1873, all of which tends to show that nearly all the water comes from the river. The microscopical examination of the water reveals the presence of much iron rust and two organisms, *Crenothrix* and *Zoöglœa*, which are frequently found in filter galleries when the filtration from a stream or pond into them is imperfect. The water of the filter gallery, notwithstanding the imperfect filtration, is a better water from a health stand-point than that taken directly from the river; but, if it were sent directly to the consumers without admixture with the river water and without passing through the reservoir, it would undoubtedly cause much complaint, and be an unsatisfactory water for domestic use.

The history of the filter gallery also furnishes some information with regard to the quantity of water which can be obtained from the ground in this vicinity. The filter gallery is 1,300 feet long, and was sunk through a layer of sandy loam and river silt from 16 to 18 feet in thickness, down to a gravel bed which admitted water freely. The bottom of the filter gallery is 8 feet below the top of the Pawtucket dam. A short test of the filter gallery, made during the dry season of 1873, gave a yield of 1,560,000 gallons per day. The average amount pumped from the gallery during one month of the same year equalled 975,000 gallons per day, showing that the gallery would furnish about 1,000,000 gallons per day at that time by a long test. A thirty-one days' test in August, 1874, and one for twenty-one days in April and May, 1875, made the yield respectively 940,000 and 960,000 gallons per day. All of these tests were made before the filter bed was added in December, 1876. In 1877, after cleaning the filter bed, it is stated in the reports that the whole supply for three months, averaging 1,730,000 gallons per day, was taken from the filter bed and gallery. A recent thirty-three hours' test, lasting from 9 A.M., June 16, to 6 P.M., June 17, 1892, showed that the yield for the whole thirty-three hours was at the rate of 1,797,000 gallons per day. The yield during this time diminished quite rapidly, and during the last

four hours was at the rate of 846,000 gallons per day. As the filter bed had not been cleaned for a year, it is probable that it furnished very little water. The test was not continued long enough to show the permanent yield after the water stored in the ground about the gallery had been exhausted, but it is less than 846,000 gallons per day, which would indicate that the yield of the gallery has diminished since it was first used.

The information with regard to the material encountered by test wells near the Pawtucket boulevard, and the quantity and quality of water obtained by tests and analysis, has been carefully studied. The first well above the filter gallery, known as Barker Well No. 1, probably comes within the territory through which water is filtering from the river to the filter gallery. This water, as analyzed by Mr. William P. Atwood, chemist for your board, had the same characteristics as the water from the upper end of the filter gallery, but to a somewhat more marked extent. Most of the test wells have been sunk more than a mile up stream from the filter gallery, in territory not influenced by it. Water from many of these has been analyzed either by the State Board of Health or by Mr. William P. Atwood. The analyses show certain variations in quality, even in wells not far apart, and in one case in samples from the same well at different times. Some of the analyses gave unmistakable evidence that the water at some point before reaching the wells had been contaminated by sewage, while others showed a nearly normal ground water. Sewage-polluted water is characterized by a high total residue, chlorine and nitrates. A comparison of two analyses, to show the differences in the amounts of these constituents, is as follows: —

No. of Well.	Total Residue.	Chlorine.	Nitrates.	Remarks.
Pierce No. 4, . .	8.2	.82	.3294	Contaminated by sewage.
Pierce No. 2, . .	3.8	.26	.0160	Nearly normal.

The houses in the territory back from the wells are so few that it is difficult to account for the sewage-contaminated water, except upon the supposition that the waste products from these houses mingle with a comparatively small amount of water as it filters towards the river, or that night-soil has been deposited upon some of the land in this vicinity, or it may be that some of the river silt, through which this water percolates, was polluted by decaying organic matter when deposited.

Although the analyses show that some of the water has been contaminated by sewage, they also show that it has been thoroughly purified by its passage through the ground. If a large supply should be obtained in this vicinity, the dilution of the sewage-contaminated water would be very much greater. These particular analyses seem to have the greatest importance in the indication which they give that only a limited quantity of water is percolating through the ground to the river.

The most instructive analyses are a series taken in connection with a pumping test from a gang of driven wells between the boulevard and the river. This test began Aug. 8, 1892, and samples were taken on August 10, 12 and 18. The water was clear and colorless as it came from the pump, but on standing became slightly turbid in appearance and developed a little color. The most significant feature is the increase in free ammonia and iron during the test, as given below: —

[Parts per 100,000.]

Date.	Free Ammonia.	Iron.
August 10,	.0086	.0350
August 12,	.0222	.0600
August 18,	.0280	.1550

The analyses show that the water has been contaminated by sewage only to a very limited extent; but the large amount of free ammonia shows that the water has been in contact with decomposing organic matter in the ground. Whether the greater part of the supply came from the river and obtained its free ammonia by passing through a layer of silt (which contains much organic matter), or whether it came from the saturated layer of silt which overlies the sand into which the wells were driven, it is not feasible to tell. In any case, however, the large amount of free ammonia and the great increase in both free ammonia and iron as the test progressed leads to the conclusion that this would be an unsatisfactory water for domestic use. Even if this water had proved to be good in the beginning, it is altogether probable that it would deteriorate in time, as has been the case with the water of the existing filter gallery.

To sum up the results of the examinations with regard to the quality of the water, it may be said that the water in the filter

gallery has deteriorated so much by use that it is unpleasant in odor, and, after exposure to the air, in appearance, and it contains so much iron that it would be very unsatisfactory for use in the laundry; in short, while better than the river water from a health stand-point, it is an unsatisfactory water for general use; and, judging from this experience, it is probable that the water of wells driven at any point in this vicinity would after a time be open to the same objections. The test from the gang of driven wells shows that the water at this place, after pumping for a comparatively short time, was affected in the same way as that of the filter gallery, though to a less extent. The analyses of water from the other test wells where the samples were collected, after pumping with a hand pump only, are as a rule fairly satisfactory, but these do not indicate what the character of the water would be after long-continued pumping. On the whole, the tests made up to the present time show that the quality of water obtainable from the ground near the Pawtucket boulevard would not be good enough to warrant taking a supply from this place, even if the quantity should be sufficient.

The territory in the vicinity of the boulevard, and all the territory on both sides of the river from which a portion of the rainfall might find its way to wells located near the boulevard, has been carefully examined, with a view to arriving at some determination as to the *quantity* of water which might be *continuously* drawn from wells located near the river. There are two sources from which the wells might derive a supply. One is the rain which falls upon the territory so near the wells that it sinks into the ground and filters directly toward them, and the other is the rain which falls on more distant territory and finds its way into streams which pass in the vicinity of the wells. When the water in the ground is lowered by pumping, some of the water of these streams may percolate through their beds into the ground, and in this way supply water to the wells.

While it is not practicable to determine exactly how much of the rain which falls upon the adjacent territory will find its way to the wells, it is feasible to make an approximate determination of the maximum quantity to be obtained in this way. On the north side of the river there is a large tract of nearly level land, extending from the river to Varnum Avenue, and much of the rain falling upon this area would filter into the ground, while only a small proportion of it would flow off into the Merrimack River or Clay Pit Brook. This tract has an area of three-fourths of a square mile. The amount of rainfall in an ordinary year is about 46 inches, of which about one-half evaporates, leaving 23 inches to

flow off over the surface or soak into the ground. Upon this land 15 inches of the rainfall might soak into the ground, which would be equivalent to an average daily supply of 536,000 gallons. Just north of this tract is another area of 0.64 square miles, which is much less pervious and has much steeper slopes. From this territory most of the rainfall would flow off into the streams, particularly in the spring and during heavy rains. It is not, therefore, to be expected that more than 7 inches of the rainfall can be collected by direct filtration from this area, which would be equal to an average supply of 213,000 gallons per day. Still further north the upper end of Clay Pit Brook has a water-shed of 0.57 square miles; but from this territory practically all of the water would find its way into the brook.

In addition to the territory on the north side of the river, it is also reasonable to suppose that more or less of the territory on the south side would contribute to driven wells on the north side, the water filtering through porous material underlying the bed of the river; and from an examination of this territory it was thought possible that a square mile of water-shed might contribute to the wells in this way, the portion nearest the river contributing 13 inches and that more remote 7 inches, making a total contribution from this territory averaging 10 inches, equal to 476,000 gallons per day. The water-shed of the upper portion of Black Brook, amounting to 2.91 square miles, is thought to contribute all of its water to the brook; and this view is supported by the fact that, when the brook was examined from its upper to its lower end in a dry time in August, it continually increased in size from point to point going down stream, owing to accessions of ground water; and the volume at its lower end was as great as is usual in dry seasons with brooks draining the same area of water-shed, showing that no unusual proportion of the water was finding its way underground to the river. In summing up the quantities above given, we find that driven wells near the boulevard cannot be expected to derive more than 1,225,000 gallons per day from the direct percolation of rain water.

With regard to the other sources from which the wells might derive a supply, viz., the streams in the vicinity, the Merrimack River is of course the most important, owing to its proximity and the large area of river bed through which the water may filter. The best basis for estimating the quantity of water which may be obtained by filtration from the river is furnished by the experience with the filter gallery, which, with a length of 1,300 feet, originally supplied about 1,000,000 gallons per day. As the filter gallery undoubtedly draws water from a considerable

distance beyond its upper end, an extension of the gallery to double its present length in the same kind of material would not furnish nearly twice as much water. In addition to this fact, it is stated, in the report of Joseph P. Davis, C.E., to the Lowell water commissioners in 1870, that soundings were made along some two miles of the river bottom above the Pawtucket dam. Opposite the present filter gallery these soundings indicated that a portion of the gravelly bed where it extended under the river was free from silt, and had open communication with the river, but higher up the river bottom was covered with silt, so that no such communication was discovered. In view of the foregoing, it seems very doubtful if more than 1,000,000 gallons would filter for any considerable length of time through each three-fourths of a mile of river bed. It must be admitted, however, that any estimate of the quantity of water to be derived from the river is largely speculative, and not based upon well-defined data. Some additional water may filter into the ground through the beds of Clay Pit Brook, Black Brook and Stony Brook, but the quantities would be limited.

In view of the foregoing, the prediction may be made that driven wells near the boulevard, however numerous, and without regard to the amount they will furnish for a short time, are not likely to furnish permanently over 4,000,000 gallons per day, and are more likely to furnish a much smaller quantity. If the good quality of the water from this source could be assured, even a limited supply might be of value in connection with other sources; but in view of the unfavorable character by recent tests of the water obtained from the present filter gallery and the gang of driven wells, the State Board of Health does not advise your board to adopt a supply by means of a driven-well system from this territory.

With regard to the other locality, to which attention has been called by your engineer, viz., the northerly side of the Merrimack River near the mouth of Beaver Brook, the investigations up to the present time have been too limited to warrant any extended statement. The character of the surroundings render it highly improbable that any very large supply can be obtained at this place, and the growth of the city of Lowell in this direction is liable to affect the quality of the water to such an extent as to make it an undesirable source of supply.

In addition to the special examination of the driven-well system, the Board has considered in a general way the question of obtaining a wholesome supply of drinking water for your city. There are three general ways in which such a supply can be obtained:

one is by efficiently filtering the water of the Merrimack River, another by taking a supply from unpolluted streams and ponds in the vicinity of Lowell, and the third by putting in a separate supply of pure water for drinking purposes only, using the present supply for the many other purposes for which the great bulk of the water is used.

Judging from the results which have been obtained by the practical use of filters in Europe, particularly in Berlin and London, and from the success obtained in the removal of typhoid fever germs and other bacteria from water by comparatively slow filtration through suitably prepared filters at the Lawrence Experiment Station, it is reasonable to conclude that the water of the Merrimack River can be made suitable for all the purposes of a public water supply by such filtration. In order to insure such results as are here indicated, it is essential that the filter should be constructed of suitable materials, that its operation should be under constant scientific supervision, and that the rate of filtration should be comparatively slow. From the information now in the possession of the Board, it would advise that the rate of filtration should not exceed 1,500,000 gallons per acre per day. It would be necessary, before filtering the water through filters fine enough to remove the disease germs, to pass it through coarser filters, to free it from the river silt which it contains during freshets.

With regard to obtaining a supply from unpolluted streams and ponds in the vicinity of Lowell, the examinations have not been carried far enough to warrant any extended statement. There are no sources of this character which alone will furnish a sufficient quantity of water to supply the city, except Beaver and Stony brooks. The former, if adopted, should not be taken below the village of Collinsville, and even above this point it is questionable whether the water would be of satisfactory quality. Stony Brook should not be taken at a point below Forge Village. Above this point the analyses indicate that the water is better than that of Beaver Brook. If it were found feasible to construct large storage reservoirs upon it, it might furnish enough water for the supply of the city; but if it should prove insufficient the supply could be supplemented from other sources, as, for instance, the tributaries which enter Stony Brook from the west at a point nearer the city, one of which is the outlet of Nabnasset Pond. In addition to these two larger sources, there are in the vicinity of Lowell several ponds or brooks which derive their supply from water-sheds too small to furnish all the water needed by your city, but by combining several of these and building storage reservoirs upon the brooks it would be feasible to obtain a sufficient supply. It may

be said in general of the streams in the vicinity of Lowell that they drain a somewhat flat territory, containing so many swamps that the water has a higher color and contains more organic matter than is desirable. This would affect the appearance and taste of the water, however, rather than its healthfulness. Some of the ponds contain water of very satisfactory quality, but they will not by themselves furnish as much water as is needed. It does not seem improbable that, by selecting the best sources available, a fairly satisfactory water supply from unpolluted sources might be obtained; and the Board would therefore advise that this plan of obtaining a water supply is worthy of further consideration.

Accompanying this communication will be found a complete set of analyses of all test wells and possible water supplies which have been examined in the vicinity of Lowell.

Malden. The water commissioners of Malden applied to the Board (July 27, 1892) for its advice as to the propriety of taking the water of Martin's Pond in North Reading as a source of water supply; and if taken, whether the water should be drawn directly from the pond or from wells or filter-basins; also with reference to the effect of raising the level of the pond, and as to the probability of the introduction of a Metropolitan water supply within a few years. To these inquiries the Board made the following reply: —

Nov. 3, 1892.

The water of Martin's Pond has been analyzed on three different occasions, viz., in July, 1887, April, 1888, and August, 1892. On both occasions when the water was examined in the summer time it had a high color and contained so much organic matter that it would not be of satisfactory quality for water supply purposes.

With regard to the effect of raising the pond to a height of eight, ten or fifteen feet, as suggested by you, thereby forming a large reservoir, it may be said that, unless this reservoir is prepared for the storage of water by the removal of all soil and vegetable matter (which would be a very costly undertaking), the water would not probably be as good as the water now in the pond, at least for many years.

From the foregoing statements you will observe that the Board does not consider it feasible to obtain a satisfactory supply directly from this pond.

A superficial examination of the territory on the southerly and westerly sides of the pond and along the shores of Martin's Brook, which flows from the pond, indicated that a considerable quantity

of water might be obtained from the ground in this vicinity. The quantity, however, must remain indeterminate until the ground in this vicinity has been thoroughly tested. It seems very probable, however, that a sufficient supply for Malden alone for a long time in the future might be obtained from the ground without an excessive expenditure for works at and about the pond, and it is possible that by more extended works a further supply might be obtained which would be sufficient for some other community.

With regard to your other question, as to whether it is probable that there will be any Metropolitan system of water supply which will be available to you in the near future, it is not within the province of the Board to advise. It is well known, however, that many of the municipalities about Boston are short of water or are using water of inferior quality, and that the sources not already in use from which a pure supply can be obtained are so remote that the independent action of each of these different municipalities is impracticable.

MARLBOROUGH. The mayor of Marlborough applied to the Board (March 11, 1892) for its advice as to an additional source of water supply, at the same time suggesting two sources, — Fort Meadow Reservoir and Millham Brook near the Assabet River. The Board replied to this application as follows: —

APRIL 13, 1892.

Williams Pond, the present source of water supply for your city, is fed by so small a water-shed that the amount of water now drawn from it equals its full capacity in ordinary seasons, and exceeds its capacity in a series of dry years, so that a further supply is urgently needed, and should be ready for use early in 1893, if Millham Brook is chosen as the source, and by the middle of the same year if Fort Meadow Reservoir is selected.

The natural quality of the water of Williams Pond is very good, but it is becoming more and more affected by the increasing population upon the water-shed, so that, if it is to be retained as a source of water supply, it will be necessary to provide for its protection a complete system of sewerage, with which all buildings on the water-shed should be connected.

In order to ascertain the quality of the water of the different sources, samples have been collected from Fort Meadow Reservoir near its lower end and toward its upper end, just east of the causeway; from Millham Brook above and below the point where the principal northerly branch enters it and from the northerly branch, also from Williams Pond.

The water from the two branches of Millham Brook varies in quality. That of the north branch has a dark color, owing to its previous contact with vegetable matter in the swamps and meadows through which it has passed, while that from the main stream has much less color. The color of the water does not have any considerable effect upon its healthfulness, but renders it less satisfactory in appearance and taste. If the water of these brooks should be stored in a large reservoir, like the one proposed, without removing the soil and vegetable matter from its bottom and sides, it would deteriorate so that its quality for an uncertain period of years would be less satisfactory than that of either Fort Meadow Reservoir or Williams Pond. If, however, instead of taking this water from the new storage reservoir it should be pumped directly from the main stream, above the north branch, to Williams Pond, using the pond as the only storage reservoir of the system, so long as a sufficient quantity of water could be obtained in this way, the quality of the water in the pond would probably be improved rather than injured, and your city might in this way obtain a satisfactory supply for the next eight or ten years.

The only way to make an entirely satisfactory reservoir for the storage of water is to remove all vegetable matter from its bottom and sides; but if this is not done, the quality of the water stored in the proposed reservoir would be much better if it was flooded to a depth of not less than eight or ten feet, by means of a low dam, for several years before the water was taken to supply the city.

If the plan herein suggested — of making Williams Pond the only storage reservoir, to be used in connection with the Millham Brook source so long as a sufficient quantity of water could be obtained in this way — should be adopted, the pond would have to be drawn down more and more in each dry season, as the consumption of water increased, and it might become necessary to raise the high-water level of the pond.

Having regard to the quality of the water, it would probably be better to pump the water of Millham Brook into Williams Pond much of the time, rather than directly to the distributing reservoir.

The water of Fort Meadow Reservoir, so far as can be told from analyses at this season of the year, does not vary very much in quality from the water of Williams Pond. Both the analyses and an examination of the surroundings show that Williams Pond receives more sewage (including as sewage the water which filters through the ground from cesspools) in proportion to the amount of unpolluted water entering it than Fort Meadow Reservoir. A larger proportion of the sewage, however, comes to Fort Meadow Reservoir without being purified by filtration through the ground;

so that, if this source is chosen, it will become necessary to collect the sewage of the part of the city which encroaches upon the Fort Meadow Reservoir water-shed and pump it to a considerable height into the present sewerage system. Whether or not the water of Fort Meadow Reservoir will retain its present character throughout the warm weather cannot be predicted now. The shallow flowage in portions of the reservoir and the muddy bottom are unfavorable features ; but, on the other hand, the reservoir has been flooded so many years that it now has to a large extent the characteristics of a natural pond, and, if wholly controlled by Marlborough, it would have to be drawn down but little to furnish all the water required for a very long time in the future.

If this source should be selected, the water should be taken from the reservoir towards its lower end, so as to be as far removed as practicable from the streams which are most likely to bring polluted water into it. The water from this source would naturally be pumped into the pipe system in the city or into the distributing reservoir, rather than into Williams Pond, which might be abandoned in the future if its water-shed should become too densely populated.

The relative merits of the two sources presented by the city may be summarized as follows: the water-shed of Fort Meadow Reservoir, owing to freedom from swamps, is naturally better than that of Millham Brook, including the north branch, but it has the disadvantage that the thickly settled part of the city is extending into one portion of it, and to protect the water from pollution it will be necessary to collect and divert the sewage of this part of the city. The long time that the reservoir has been flooded gives it to a large extent the characteristics of a natural pond. The quantity of water to be taken from it for many years will be so small that it will not cause any large fluctuations in its level, and it will furnish without an excessive draft upon it an ample supply of water for three times the present population of your city. The water at the present time is as good as that of Williams Pond, but it cannot now be predicted whether it will remain so throughout the warmer portions of the year.

The Millham Brook source has the advantage that it has a smaller present and prospective population upon its water-shed, and, in connection with Williams Pond as a storage reservoir, a portion of the system can be built and used for several years without building the whole. If the sewage is diverted from Williams Pond, as before suggested, the quality of the water will probably be as good or better than at present for as long a time as the main brook and Williams Pond will furnish a supply

without using the large storage reservoir. After it becomes necessary to use the large storage reservoir, the water from this source may be somewhat less satisfactory in quality than that from Fort Meadow Reservoir, unless the soil and vegetable matter are removed from its bottom and sides, at a very large expense.

The Board cannot at the present time reach a conclusion as to which of the sources presented by the city is the most desirable, taking into account both the present and the future, which may not require reversal when further information is obtained regarding the character of the water later in the season in Fort Meadow Reservoir and in Millham Brook. The choice is also dependent to a considerable extent upon the estimated relative cost of taking water from the two sources, including in the estimates the cost of water and land damages, construction and maintenance, both in the beginning and in the future, and the cost of protecting the water supply by the diversion of the sewage. The Board therefore believes it desirable that the city should, if possible, obtain authority to take either of the proposed sources, as may be found most desirable after further information is obtained. If it becomes necessary to decide upon a single source at the present time, there is so little difference in the two sources with regard to the quality of the water that you would be justified in making the choice depend mainly upon the relative cost, which can be determined better by you than by this Board.

The Board would add that, after a general investigation of other surface water sources in the vicinity of Marlborough, it did not find any which appeared to be better than those presented by the city.

If you so desire, the Board will continue its investigations of the proposed sources of water supply, and will give you further advice regarding them later in the season.

MEDFIELD. E. V. Mitchell and others applied to the Board (Jan. 28, 1892) with reference to a proposed water supply for Medfield, to be taken from springs in the valley of Vine Brook, about a third of a mile above North Street in Medfield. The Board examined this region and examined the water of the proposed source, and stated its approval of the same as an appropriate source of water supply for Medfield.

THE MEDFIELD INSANE ASYLUM. The trustees of the new insane asylum at Medfield applied to the Board (Oct. 3, 1892) for its advice relative to a proposed source of water supply and a system of sewage disposal for the asylum. The Board replied as follows : —

Nov. 3, 1892.

By the plan submitted, the water supply is to be taken from a system of driven wells located near the Charles River upon land belonging to the asylum. This location has the advantage of proximity to the proposed asylum buildings and of freedom from all sewage contamination, and the further advantage of having a large river near it to assist in keeping the ground saturated. The quality of a sample of water collected from a test well driven at this place was excellent, as the water was very soft and pure.

It seems very probable, from the results of the test wells which you have driven and the surface indications at this place, that the relatively small quantity of water needed for the asylum can be obtained without difficulty. It would be a wise precaution, however, to ascertain further the character of the ground by driving a part or all of the permanent wells before building other portions of the plant for taking a supply from this place.

MEDWAY. E. V. Mitchell and others applied to the Board (February 1) for its advice relative to certain proposed sources of water supply in that town, and the Board replied as follows: —

MARCH 1, 1892.

The sources mentioned in your application are "springs on and in the vicinity of Dry Bridge Hill, so called," "Chicken Brook, and the springs in the vicinity of said brook and which flow into the same," and "springs near Charles River near Woodland Park, all in said Medway."

The Board has caused an examination of these sources to be made, and is of opinion that the springs upon Dry Bridge Hill will not furnish a sufficient quantity of water for the supply of the town.

The proposed ground water source near Charles River is objectionable on account of the polluting matter from the settled portion of the town, situated above the source, which would find its way to a well located at this place.

Chicken Brook would furnish an abundant supply of water, but of an inferior quality. It does not appear probable that a sufficient supply of ground water can be obtained near this brook at the place pointed out to our engineer.

In view of the unsatisfactory character of the sources named by you, the Board advises that you have investigations made to determine whether a source cannot be found from which a sufficient quantity of unpolluted ground water can be obtained for the supply of the town.

MILLBURY. The Millbury Park, Forestry and Water Company applied to the Board (Nov. 17, 1892) for its advice relative to taking water from springs near the Millbury branch of the Boston & Albany Railroad Company. The Board replied as follows: —

DEC. 1, 1892.

The State Board of Health, in 1888, in response to an application made by the town authorities of Millbury, investigated the different sources of water supply available for the town, and, among others, springs adjoining the Millbury branch of the Boston & Albany Railroad, near the old Worcester road. With regard to this source the Board made the following reply, which it finds no reason to modify: —

"After careful examination of the different sources of water supply for the town of Millbury, excepting that of the Worcester water works, which has been mentioned but is understood to be unavailable, the State Board of Health finds that the site selected for a ground-water supply has advantages which make it the most appropriate source for the town. Analysis of water from the flowing well showed it to be very soft, and of excellent quality. The quantity that can be obtained from the immediate locality of the present well cannot be determined until proved by months of pumping, and other wells may be needed to intercept all of the water that may be required; but the surroundings indicate that a sufficient quantity, for a long time in the future, may be brought to a pumping station in the vicinity of the present well. The Board advises that water taken from the ground should, when stored, be in a reservoir from which light is excluded."

MILLIS. Application was made (Jan. 20, 1892) by Henry L. Millis and others for the advice of the Board relative to taking the water of Aqua Rex Spring in Millis as a source of supply for that town. The Board, after having caused an examination of the region and of the water, approved the same (Feb. 15, 1892) as an appropriate source of supply for Millis.

MILTON. The water committee of Milton notified the State Board of Health (Nov. 29, 1892) that it had been appointed by the town to investigate the affairs of the Milton Water Company in regard to the advisability of

purchasing the works of the company, and asked the advice of the Board as to the purity of the present source of supply, namely, that of the Hyde Park Water Company, to which the Board replied as follows: —

JAN. 5, 1893.

The source from which the Hyde Park Water Company obtains its supply is the ground near the Neponset River. Until the summer of 1892 it is understood that the supply was taken wholly from a system of driven wells, and at this time, in order to prevent a deficiency, water was also drawn from a large well in the vicinity known as the starch factory well.

Analyses of water pumped from the driven-well system were made each month for two years from June, 1887, to May, 1889, and at less frequent intervals since that time. A comparison of these analyses shows that there has been a noticeable increase in the amount of organic matter contained in the water, but up to a recent date the amount has not become so large as to lead the Board to conclude that the water is not of suitable quality for the purposes of a public water supply.

An examination of water from the starch factory well, made last summer, showed that it derived its supply, at least in part, from the Neponset River, and that the water was imperfectly purified by filtering through the ground. The Board then reached the conclusion, and expressed its opinion, that the use of water from this well was liable to endanger the public health.

As a substitute for the supply which was derived from the starch factory well last summer, and also to provide for the increasing quantity of water necessary to supply the towns of Hyde Park and Milton, more water will have to be drawn from the present driven-well system, or the works will have to be extended. It is probable that a portion of the supply drawn from the driven wells comes from the Neponset River, and that the degree of purity which the water now attains is due to the purifying power of the ground through which it filters. Any extension of the works in this vicinity would also be likely to obtain a considerable portion of the supply by filtration from the river. It is obvious that in a case like this, where a supply is to be taken from the ground so near a polluted stream, much care will have to be taken in order to prevent the entrance of imperfectly filtered water into any part of the system, and the extension of the works must be made wisely in order to obtain thorough purification.

NANTUCKET. The town of Nantucket, through its committee on water supply, applied to the Board (Sept. 3,

1892) for its advice relative to the most appropriate source of supply for the town, at the same time indicating two ponds (Gibb's and North Head of Hummock) as possible sources of supply. The Board replied to the application as follows: —

Oct. 6, 1892.

Either of these ponds would probably furnish all of the water required to supply the town. The water of Gibb's Pond at the present time has a moderate amount of color, but it is a comparatively clear water, and in other respects is shown by analysis to be of good quality, so that at the present time it would be a fairly satisfactory water for domestic use. The water of North Head of Hummock Pond, on the contrary, had a disagreeable odor, was rendered turbid by a large quantity of minute vegetable forms floating in it, and was not a suitable water for domestic use. In order that a comparison might be made with the water of the present source of supply, a sample was also taken from Wannacomet Pond, and the analysis showed it to be a better water than that of Gibb's Pond. This relation between these two waters might not exist at other times, however, as the analysis of waters stored in ponds and reservoirs changes very much from time to time, as they contain more or less of the minute animal and vegetable growths which are liable to occur in such waters, particularly at Nantucket, and at times render them very disagreeable to taste and smell.

It is probable that water of better quality than either of these ponds may supply at some seasons of the year may be obtained from the ground beyond the settled parts of the town; and, if the town proposes to put in a new water supply for domestic purposes as well as for fire protection, it would be advisable to have the question of obtaining a supply from the ground carefully examined. Judging from the surface indications, an abundant supply of good water might be obtained from the ground in some parts of the island, provided material can be found which is coarse enough to permit water to pass freely to driven or dug wells.

Newburyport. Information was received by the Board (Sept. 26, 1892) to the effect that there was evidence that the water furnished by the Newburyport Water Company had at times been pumped from the Merrimack River. The State Board of Health investigated the matter, and sent the following statement to the Newburyport Water Company: —

Nov. 3, 1892.

The State Board of Health has been informed that the water of the Merrimack River has at times been pumped into the pipes of the Newburyport Water Company and distributed to the citizens of Newburyport.

The Board, as a result of extended examinations of the effect of using the Merrimack River water at Lowell and Lawrence, reached the conclusion that it is to this cause that the excessive mortality from typhoid fever in these cities, as well as the very severe epidemic of this disease in the winter of 1890–91, may be ascribed. The condition of this river at Newburyport is worse than at either Lowell or Lawrence, owing to the added sewage of the cities of Lawrence and Haverhill and the town of Amesbury.

In view of this condition of affairs, the Board is of opinion that the Newburyport Water Company should obtain a further supply of pure water without delay, so that there will be no further occasion for pumping water directly from the river.

North Brookfield. The water commissioners of North Brookfield applied to the Board (Jan. 1, 1892) for its advice relative to the taking of Horse and Doane's ponds in that town as appropriate sources of water supply. The Board replied as follows: —

Feb. 3, 1892.

It is proposed to take Horse and Doane's ponds, located within the town, but to construct the works so that the water for the supply of the town will be taken from Doane's Pond, except in cases of emergency, or in case this water should be poorer than that stored in Horse Pond, when the water of the latter may be used. At other times the water from Horse Pond and the swamp between it and Doane's Pond will be used for pumping by water power, or wasted below the dam of Doane's Pond. It is also understood that the dam at Doane's Pond is to be raised about five feet, so as to increase the storage capacity in this pond.

In addition to these changes mentioned in your application, Doane's Pond should be carefully prepared for the reception of water by cleaning it out, by removing the vegetable matter from the bottom and sides, particularly from the land which will be flowed when the pond is raised, and by deepening or filling the shallow portions, so as to prevent shallow flowage. If the works are constructed as here indicated, the quality of the water obtained from this source will probably be satisfactory.

Other sources in the vicinity of North Brookfield have been brought to the attention of the Board by you, and the sizes and

elevations of still other streams and ponds have been examined by means of the new topographical map of the State; but the Board has not found any other available source which is likely to furnish as satisfactory results as to the quantity and quality of water supplied as the one which you have presented. It therefore recommends and advises that you take Doane's Pond and its tributaries, including Horse Pond, as a source of water supply for your town.

PITTSFIELD. The board of public works of Pittsfield applied to the State Board of Health (Dec. 11, 1892) for its advice relative to the propriety of taking the water of Hathaway Brook in the towns of Washington and Dalton, Mill Brook in Washington and Lenox, and Sykes Brook in Pittsfield, as additional sources of water supply for Pittsfield. The Board replied as follows: —

FEB. 2, 1892.

The present sources of water supply for your city are Ashley and Sackett brooks, situated about four miles south-easterly from the city. The waters of these streams are usually taken at such a height that the city is supplied by gravity. The total water-shed above the dams where the waters are taken, as measured from the new State map, is 5.39 square miles. The natural flow of these streams during the dryer portions of the year is too small to supply the city, and the additional quantity of water required at such times has in the past been obtained from Ashley Lake, which has an area of eighty acres and is located at the head of Ashley Brook.

As the capacity of the gravity sources in a dry time has been reached, a temporary pumping station has recently been erected under the authority granted by chapter 155, Acts of 1889, to take water from Sackett Brook below its junction with Ashley Brook, and far below the level at which these streams can be taken by gravity. In this way an additional water-shed of 3.59 square miles is made available for supplying the city.

It is understood that the sources mentioned in the application are asked for with a view to using them for increasing the gravity supply so as to diminish, if not to entirely do away with, the necessity of pumping. Of the sources mentioned in the application, the water of Sykes Brook has not been examined, because this stream is so small above the point at which its waters could be taken by gravity that it will be practically valueless as a source of additional water supply. The water of Mill Brook is shown by analysis to have substantially the same character as that which has been supplied to the city in the past. The water of Hathaway

Brook is nearly twice as hard, but might not give any trouble on this account, because it would furnish only a small portion of the supply, and consequently would not increase very much the hardness of the water as delivered in the city. If this brook is taken, it should be in such a way that its waters would run to waste whenever a sufficient supply of softer water from the other brooks can be obtained.

Judging from the best information obtainable at present, the addition of these two brooks would increase the capacity of your present gravity sources about forty per cent. in a very dry year, but would not furnish forty per cent. more water than is now supplied to the city, because the amount now used is considerably in excess of the capacity of the present gravity sources in such a year. These sources, therefore, would not be likely to supply the city for a very long time in the future, unless the consumption of water is restricted by the adoption of measures to prevent the waste of water.

It is probable that further increase of ten per cent. in the amount of water supplied by gravity could be obtained by raising Ashley Lake about two feet, provided the lake has a water-shed large enough to fill it when it is drawn down to the lowest level.

The addition of the two brooks above mentioned and the raising of the lake appear to be about all that can be done to increase the gravity supply from the high land on the east side of the river, and to obtain a further supply it will probably be necessary to resort to pumping.

The sample of water collected from Sackett Brook opposite the temporary pumping station was of good quality, in every way, for drinking; but the water is harder than that of Hathaway Brook, and about three times as hard as that of the present gravity sources, which would render this water very unsatisfactory if it was the main source of supply. If only a small portion of the water came from this source, it might not increase the hardness of the water delivered in the city enough to make it objectionable.

Another source which has been examined is Onota Lake, a little more than a mile west of the city. The water in the southern division of this lake has been analyzed at three different times. This water is somewhat harder than that now supplied to the city, but is softer than that of Hathaway Brook, and very much softer than that from Sackett Brook opposite the pumping station. In other respects, the water of this division of the lake is of very good quality, although not as good as the water from the mountain streams. The quantity of water which this lake will furnish will meet all the requirements of the city for a very long time.

It is stated in your application that you have petitioned the Legislature for authority to take the three brooks named therein. The right to take the waters of Hathaway Brook appears to have been already granted to you by chapter 163 of the Acts of 1874 and chapter 155 of the Acts of 1889. Sykes Brook is so small that it does not seem worthy of consideration, which leaves only Mill Brook to be considered further.

With the information now at hand the Board is in doubt as to whether Mill Brook, which is outside of the city limits, is a desirable source of supply for the city of Pittsfield; and, as the needs of the city are temporarily met by a pumping station near Sackett Brook, the Board would suggest the desirability of making the following estimates, surveys and investigations before proceeding further in this matter: —

1. An estimate of the cost of works for taking water from Mill Brook by gravity.

2. An estimate of the cost of a gravity connection with Hathaway Brook.

3. A survey of Ashley Lake, to determine its available storage capacity, and whether it can be flowed to a higher level.

4. Estimates of the cost of raising the dam at Ashley Lake and improving its shores.

5. A survey of the water-shed of this lake, as a basis for estimating whether it will fill in a dry year if the dam is raised.

6. An estimate of the cost of taking an additional supply from Onota Lake by means of a pumping station at its southerly end.

In connection with these investigations it would be advisable to have the waters of the different available sources analyzed from time to time, so as to determine their general character better than it can be determined by single analysis.

It may also be advisable to make some preliminary examinations, to determine whether improvements can be made at West Pond and in its vicinity, which will make the water in this pond and Roaring Brook of suitable quality for domestic use.

When you have further data to present the Board will advise you further upon this subject.

Provincetown. Application was made to the Board by the committee on water supply of Provincetown in 1889 with reference to a proposed water supply for that town, and the reply of the Board is published in the report of the State Board of Health for that year. Application was made by the water board (Aug. 9, 1892) for the advice of the

State Board of Health, after tests had been again made as to the character of the ground water within the limits of the town. To this application the Board replied as follows: —

Oct. 6, 1892.

In regard to the quantity of water there is no reason to doubt that an ample supply can be obtained from the ground at the place where the pumping test was made.

The water as it comes from the ground has a decided odor, a noticeable taste and a moderate amount of color. The odor disappears quite rapidly when the water is exposed to the air, and still more quickly when agitated, so that there is little doubt that it can all be removed from the water by efficient aeration and exposure to the air. The taste disappears to a considerable extent with the odor, and not enough remains to make the water seriously objectionable. The color of the water increases after it is drawn from the ground, this result probably being produced by the oxidation of the iron dissolved in the water.

All samples pumped from the test wells with the steam pumps were shown by analysis to contain a large amount of iron in solution. There is doubt, however, as to how much of the iron came from the ground and how much from the large uncoated wrought-iron pipes which connected the wells with the steam pumps; because a sample obtained by pumping with a hand pump directly from one of the wells four weeks after the pumping test was concluded contained only half as much iron as samples pumped from the same well with the steam pumps. Another sample collected from one of the small observation wells in this vicinity contained only a very little iron, the amount being less than one-tenth as much as in the last sample mentioned, which was collected on the same day.

In view of this variation in the results obtained from samples taken in the same vicinity, but under different conditions, there is much uncertainty as to how much the presence of iron in the water will affect a supply from this source. The present indications are that the water will not be satisfactory for laundry purposes unless the iron is removed from it in some way. A portion of one of the samples, which contained a large amount of iron, by being passed through a sand filter which also contained a small amount of alumina, had all the color and nineteen-twentieths of the iron removed from it; but whether a similar result could be obtained by filtering the water intermittently at a practicable rate through the sand found at Provincetown can only be told by experiment.

From a health stand-point the water from the proposed source

would be very much better than that taken from private wells in the town, where the porous sand permits a very free communication between the cesspools and the wells. Analyses were made of the water of six wells in the town, and only one was found to be entirely free from contamination. In some cases the water was polluted to such an extent as to render it dangerous to health, and in other cases there was evidence of contamination, though to a less extent. The water from the proposed source is soft, while that of most of the wells in town was hard, a result which is due to the percolation of water from cesspools into the wells.

The conditions at Provincetown in regard to a water supply are different from those in other parts of the State, so that it is impracticable to judge from experience elsewhere whether the water taken from the proposed source will improve or deteriorate with long-continued pumping.

The Board is unable to advise the introduction of the water from the proposed source, and advises further search to see if a source cannot be obtained which will be satisfactory. The Board of Health will continue to co-operate with your board in making such examination.

Further tests were then made by the water commissioners, and another application was made to the State Board of Health for its advice (Nov. 28, 1892). To this application the Board replied as follows: —

Dec. 3, 1892.

The State Board of Health acknowledges the receipt of your communication of Nov. 28, 1892, in which you call attention to the last paragraph in the reply of the Board, dated Oct. 6, 1892, and state that you have, as there recommended, made further search for a better source of water supply by testing in three other localities, with no better results. You also say, "We have been over all the available territory for a water supply, and are of opinion that no better water can be found for a town supply than the proposed source where our wells are located."

From your statements, from analyses of samples of water which you have sent to the Board during recent investigations, and from a study of a recent map of Provincetown based upon surveys made this year, the Board finds no reason to doubt your conclusion that the source where your temporary pumping station was located will furnish as good water as any other in the town. The character of the water from this source was fully set forth in the former reply of the Board. As this water is entirely uncontaminated by sewage, and from a health stand-point is very much better than water taken

from private wells in the town, even though somewhat unsatisfactory in other respects, the Board is of opinion that you will be warranted in adopting this source for supplying the town. If after the works have been in operation a considerable time the water should prove to be of unsatisfactory quality, it may become necessary to improve it by filtration or otherwise, or to go beyond the limits of the town for a better source of supply.

The views of the Board, based upon its present data, with regard to the feasibility of improving the character of the water by aeration and filtration before it is delivered to the consumers, are stated in the previous reply.

South Hadley. The water commissioners of South Hadley applied to the Board (Feb. 9, 1892) for its advice as to the propriety of taking the water of Leaping Well Brook as an additional source of supply, and the Board approved the same as suitable for domestic use.

Stoneham. Under the provisions of chapter 278 of the Acts of 1892, the joint board authorized by chapter 160 of the Acts of 1870, together with the selectmen of Stoneham, were constituted a board "to establish rules from time to time to regulate the entering in and upon the waters of Spot Pond in Stoneham, so far as they may deem necessary for maintaining their purity as a source of domestic water supply." By the provisions of the same act of 1892, the State Board of Health was authorized to "inquire into and rescind any rule or regulation which the said board shall determine unreasonable," after the receipt of a copy of any rules adopted by this joint board of water control. Very soon after the enactment of the act to preserve the purity of the waters of Spot Pond, the joint board, therein mentioned, adopted the following rules: —

Rule 1. All persons are hereby forbidden to enter in, upon or over the waters of Spot Pond, or to allow any animal or animals under their control to enter therein, except as may be hereafter provided.

Rule 2. Permits to boat, fish, skate or to cut ice on said pond may, on written application, be granted by the joint board authorized to regulate the entering upon said pond by section 2, chapter 278 of the Acts of 1892, under such restrictions as the

said joint board may from time to time establish: *provided, however*, that no permit shall in any case be granted to keep boats on said pond for public use or for hire. Permits to be for such time as the board may determine, the same to be stated in the permit, and may be revoked by them at any time, but shall not be transferable.

On June 23, 1892, the selectmen of the town of Stoneham applied to the State Board of Health, as authorized by section 3 of the above-mentioned act, and requested them to inquire into the rules and regulations which had been adopted by the joint board of control, and to "rescind such rules as the State Board should determine to be unreasonable." The Board, after considering the matter, sent the following reply to the selectmen of Stoneham: —

Aug. 8, 1892.

In reply to your application to this Board relative to certain regulations adopted by the joint board of control for preserving the purity of the waters of Spot Pond, the State Board of Health considered the question at its last meeting and passed the following vote: —

"That the Board does not at present find reason to rescind the regulations of the joint board, adopted under the provisions of chapter 278 of the Acts of 1892. If, however, the authorities of Stoneham desire to be heard in regard to the matter, the Board will grant a hearing to all interested parties at a future day."

Stoughton. The town of Stoughton having, by authority of a vote, taken the franchise and plant of the Stoughton Water Company, the water commissioners of that town applied to the State Board of Health (April 13, 1892) for its advice as to a new source of supply, and designated for consideration the region near Knowles Brook and Muddy Pond. The Board replied as follows: —

May 5, 1892.

Analyses of the water coming from the ground at both of these places show that the quality of the water, if properly collected, will be excellent in both cases, so that the decision as to whether either one or both of these sources should be taken will depend upon the quantity of water which they will furnish in a dry year, and the cost of obtaining the supply.

Judging from examinations of the water-sheds of the two sources

and from gaugings of the streams it is probable that Knowles Brook will furnish in the dryest year a supply for the whole of the present population, and that Muddy Pond will furnish a supply for nearly, if not quite double, the present population. These estimates are based upon the assumption that loose, gravelly ground can be found in both of these locations to a depth of from thirty to forty feet, and may require modification if examinations of the ground, which should be made before any final decision is reached, show that this is not the case.

Either of these sources can, if necessary, be supplemented by a supply from the other. If Knowles Brook should be chosen in the beginning, a supplementary supply can be obtained from the ground near Muddy Pond by means of wells and a pipe connection, which would convey the water to Knowles Brook by gravity. If the Muddy Pond source should be chosen, it would be necessary, in order to obtain a supplementary supply, to establish a second pumping station and wells at Knowles Brook. Such a pumping station, however, would not probably be required until the town contains double the present population, and even then would have to be operated only during the very dry portion of the year, as the Muddy Pond source will in all ordinary times furnish a very abundant supply of excellent water for more than double the present population.

The Board is therefore of opinion that the most appropriate source from which to obtain a water supply for Stoughton is the ground in the vicinity of Muddy Pond, provided further examinations show that porous material at this place is of sufficient depth and extent.

UXBRIDGE. The selectmen of Uxbridge applied to the State Board of Health (Oct. 3, 1892) for advice relative to a proposed water supply for the town, indicating two sources for consideration, Nipmuck or Mendon Pond in Mendon, and springs in the valley of Crony Brook. To this application the Board replied as follows: —

Nov. 4, 1892.

The plan submitted shows two sources for obtaining a further water supply for the town: one is a pond in the town of Mendon, known as Nipmuck or Mendon Pond, and the other some springs just above the Carpenter Hill Road in the valley of Crony Brook. Examinations of both of these sources and analyses of water from them have been made.

Nipmuck Pond is of sufficient size and has a sufficient water-shed to supply all the water required by the town of Uxbridge for a very long time in the future. The analysis shows that its water is very soft and nearly colorless, and it contains only a moderate amount of organic matter either in suspension or solution. It is, however, found by microscopical examination to contain a variety of minute organisms, mostly vegetable, such as are quite commonly found in ponds and storage reservoirs, and these organisms give the water at the present time a pondy taste, a very faint odor when cold and a more decided odor when heated. These odors are noticed when the water is agitated in a large bottle, and would be noticed much less if at all in water standing in an open vessel. Tastes and odors in pond waters come and go, so that it is not feasible to tell from a single examination how much this water may be affected by them. In the waters of some ponds and storage reservoirs they occur frequently, while in others only at long intervals or not at all. While it is not feasible to predict with any certainty how much the water of Nipmuck Pond may be affected by these troubles, the information available at the present time leads us to think that this water would not give more than a moderate amount of trouble in this way.

The water from the springs in the Crony Brook water-shed is of the same excellent quality as that now supplied from the existing works to the main village. By diverting the water of these springs into the present reservoirs a further supply of excellent water could be obtained, but the quantity would be small. With a view to obtaining a larger quantity of water from this source, it is proposed to develop its capacity by building a dam to raise the water twelve feet and create a reservoir which will contain about three million gallons. By this plan the spring water would merge with that flowing over the surface into the reservoir in the spring or during heavy rains, and the quality of the water would be likely to deteriorate by storage in such a reservoir, though it might still be of satisfactory quality if the reservoir is carefully prepared by removing all soil and vegetable matter from its bottom and sides.

The total amount which this source will furnish when such a reservoir is constructed cannot in any case be large, and it is not improbable that when the water is raised twelve feet the pressure might cause a considerable portion of it to filter through the ground and appear as springs in the valley below, which might reduce the yield from the reservoir so that it would not be much in excess of the yield of the present springs.

As a result of its examination, the Board is of opinion that Nipmuck or Mendon Pond in the town of Mendon is the only

single source from which a sufficient future supply of water for the whole town can be obtained by gravity, and the quality of the water is such that the town would be warranted in taking a supply from this source. If, however, works are not to be constructed at once, it would be advisable to have repeated examinations made, to determine the character of this water at different seasons of the year.

The Board is not satisfied that the additional amount of water that may be obtained by building the proposed dam on Crony Brook will warrant the expense of construction.

WALTHAM. The water commissioners of Waltham applied to the State Board of Health (Aug. 9, 1892) for its advice relative to "what measures, if any, were necessary to preserve the purity of its water supply." The Board replied to this application as follows: —

OCT. 3, 1892.

The examinations indicate that the water as it comes from the ground into your well and filter basin, whether derived from the Charles River or from territory which contributes water directly to the well, is very thoroughly purified by its passage through the ground, so that it is colorless and free from odor, and contains only a very small amount of organic matter. In the well and filter basin, however, before it is pumped its quality rapidly deteriorates, and it develops at times a disagreeable odor, owing to the rapid growth of certain low forms of vegetation in the water. After the water is pumped to the reservoir still other vegetable forms appear, many of them minute microscopical forms, which are suspended in the water and render it slightly turbid. These minute forms, either in the reservoir or after they are drawn into the pipes with the water, are probably the chief cause of the disagreeable tastes and odors observed at times in the water as drawn from taps in the city. In addition to the direct effects of this vegetable growth, both the fresh and the decaying vegetable matter help to support animal life.

The remedy for all of these troubles is, as suggested in the former reply of this Board to the city of Waltham, dated March 3, 1891, the exclusion of light from the water from the time it comes from the ground until it reaches the consumer. This would prevent all of the vegetable growths which are now found in the water, and would indirectly prevent animal growth, as its supply of food would be cut off. There is no reason to think from the experience obtained with other Massachusetts water supplies that

a water of as good quality as that which now comes into your well and filter basin would support any growth which would cause it to deteriorate in quality if light were excluded.

The best method of excluding the light is a matter for study and decision by your Board. The walls of the well might be raised above high-water mark and covered with a roof, and the surrounding basin might be filled in without affecting the ultimate capacity of the supply. If, however, it is thought necessary to preserve the storage capacity of the basin so that water can be pumped more rapidly for a limited time, the portions outside the wall might also be covered. Covering the present distributing reservoir would be effective, but somewhat difficult on account of its shape and size, so that some other method may be cheaper or possess additional advantages. If, as suggested by members of your board, an increased pressure is desirable in some parts of the city, it may be best to build a new covered reservoir or tank at a higher level and of sufficient size for all ordinary uses, reserving the present reservoir for use in case of fire or other emergency. There is reason to suppose that covering the well and filter basin would improve the quality of the water, but no great improvement could be expected if the water is exposed to the light at any place.

There is one other way in which the quality of the water is threatened, viz., by the cesspools and sewage from the rapidly growing population on the territory known as "The Island," just across the river from the pumping station. A part of your water supply undoubtedly comes from this territory, and the abolition of cesspools and the diversion of the sewage from it into the Metropolitan system should be provided for without delay.

WEST BOYLSTON. The selectmen of West Boylston, together with a committee of the board of trade, applied to the State Board of Health (Nov. 19, 1891) for its advice relative to a proposed water supply from Malden Brook, to which the Board replied as follows: —

JAN. 27, 1892.

The water of Malden Brook has a high color, and contains more organic matter than is desirable in a brook used for water supply purposes. As, however, both the color and the organic matter are derived from vegetable sources, there is no reason to think this water would be injurious to health.

In order to obtain the necessary quantity of water from this source in a very dry year, it would be necessary to provide a small storage reservoir, which should have all vegetable matter removed

from its bottom and sides, as the water would otherwise deteriorate in it.

As this source, though permissible, was not entirely satisfactory, the Board caused an analysis to be made of the water of Trout Brook, which is a larger stream, and would furnish the quantity of water required to supply the town without building a storage reservoir. The water had a little more color but contained less organic matter than the water of Malden Brook, and it has the further advantage that it would not be necessary to store the water, so that, although it would have a somewhat peaty taste, it would not be subject, judging from our present knowledge, to the bad tastes and odors which frequently affect waters when stored. This source has a smaller population per square mile on its water-shed than Malden Brook, and it is therefore less likely to be polluted. On the whole, it may be said that the quality of the water supply from this brook would be better than one from Malden Brook.

In many places in the State a very satisfactory water supply has been obtained from wells sunk in porous gravel in the low land adjacent to some stream or body of water; and preliminary examinations indicate that a supply of this character might be obtained for West Boylston, although it would be necessary to pump the water.

As already indicated, the Board is of opinion that a sufficient quantity of water for the supply of your town can be obtained from Malden Brook by building a reservoir of moderate size, and the quality is as good as that of the water supplies of many places in the State where the water supplied is fairly satisfactory.

The Board, however, does not advise the adoption of this source until the town has made a more thorough investigation, to determine if a more satisfactory supply cannot be obtained.

WILLIAMSTOWN. The Williamstown Water Company applied to the Board (March 22, 1892) for its advice relative to a proposed additional supply of water from Paul Brook, upon the northerly slope of Saddle Mountain, and lying partly in Williamstown and partly in North Adams. The Board replied as follows: —

APRIL 6, 1892.

The State Board of Health has caused an examination of the premises to be made, and advises that a large addition to your present supply can be obtained from this source.

It is not feasible to tell in advance, however, whether the proposed source will furnish a sufficient quantity of water in connection with the present sources to supply the town in a very dry

time; but, in view of the comparatively small outlay required to utilize this source and the very good quality of the water, the Board is of opinion that it is an appropriate source from which to obtain an additional supply of water.

WINCHENDON. An application was received from Sophia M. Whitney of Winchendon for the advice of the Board relative to a proposed "system of water works" in that town, to which the Board replied as follows: —

APRIL 8, 1892.

Your application, dated March 26, to the State Board of Health for its advice with regard to a proposed water supply to be brought into the village of Winchendon from a deep well on Benjamin Hill and distributed for domestic purposes has been considered. The Board has caused an examination of the surroundings of the well and an analysis of its water to be made and finds that the water is of excellent quality. The quantity of water which the well will furnish during a dry season cannot be at all closely estimated in advance, because of the uncertainty as to how much of the water percolating through the ground in the vicinity of the well will flow past it and come out at lower levels. It is obvious, however, from the size of the water-shed above the well that it cannot furnish a sufficient supply for any large portion of the village.

The Board is of opinion that the proposed source is an appropriate one for as many takers as can be supplied by it in an ordinary time, unless it interferes with the introduction of a general system of water supply in the town.

WINTHROP. The committee on water supply of the town of Winthrop applied to the Board (Aug. 22, 1892) for its advice relative to the propriety of taking a supply of water for the town from wells situated between Pauline and Lincoln streets in that town. The Board replied as follows · —

OCT. 7, 1892.

At the time an examination was made by an engineer of the Board five wells had been driven in Ingalls Meadow in a line extending out from its edge, and a sixth well at the edge of the meadow. A sample collected from the well at the edge of the meadow was found upon analysis to be a water which had at some time been contaminated to a considerable extent by sewage, and had been very thoroughly purified by its subsequent passage through the ground; while a sample taken at the same time from

one of the wells driven in the meadow showed a little less sewage contamination, but contained a large amount of iron, which separated from the water upon standing, making the water turbid, and producing a heavy rusty sediment on the bottom of the bottle in which the water stood. A third sample was obtained from the five wells in the meadow after they had been connected and tested by pumping from them with a steam pump. This sample was about the same as regards sewage contamination as the previous sample from the well in the meadow. It contained less iron than the previous sample, but enough to make it unsatisfactory for laundry purposes. In other respects it was an unsatisfactory water for the purposes of a public water supply.

With regard to the quantity of water to be obtained from this source, it is not at all probable that it will furnish permanently as large a supply of water as is now used in the town, and it is manifestly inadequate to meet the future requirements of your rapidly growing population.

In view of these results, the Board is of opinion that the source submitted is not a proper one from which to obtain a water supply for the town of Winthrop. It may be added that a general examination of the town did not reveal any place where a larger supply of fresh water could be obtained.

Sewerage and Sewage Disposal.

The following is the substance of the action of the Board with reference to such questions pertaining to sewerage and sewage disposal as were submitted to it during the past year: —

Brockton. The mayor of Brockton applied to the State Board of Health for its advice with reference to a partial system of surface drainage (March 10, 1892), designed for the Howard Street district in the northerly part of Brockton. This application was made under the provisions of a special act (chapter 309 of the Acts of 1888), entitled "An act to authorize the city of Brockton to provide for surface drainage and to improve the brooks and natural streams within the limits of said city." By the terms of section 9 of this act "such system of drainage, before its construction, shall be subject to approval by the State Board of Health, who may modify and amend the same if desirable." After careful

consideration of the question, the Board approved the system referred to, April 8, 1892.

BROOKFIELD. In 1891 the selectmen of Brookfield applied to the Board for its advice relative to a system of sewage disposal having its outlet in a meadow north of the village. The plan was not approved by the Board, and on Jan. 22, 1892, another plan was submitted, having a temporary outlet into the Quaboag River. To this application the Board made the following reply: —

FEB. 3, 1892.

This plan provides for the removal of the sewage by a system of small pipe sewers, designed to take sewage only, and is provided with an outlet into the Quaboag River on the line of Howard Street extended. The plan also shows an alternative line for the main sewer, by which the sewage can be diverted to porous land south-east of the village, and there purified by filtration before entering the river.

In view of the much greater cost of the plan for purifying the sewage, and the comparatively small amount of sewage which your village will contribute, the Board is of opinion that an outlet into the river is permissible for the present; but adds the warning that the time will probably come when an alternative plan of purification of the town's sewage by filtration on the land before permitting it to enter the river will be imperative.

HULL. The selectmen of Hull applied to the Board (Dec. 24, 1891) for its advice relative to a proposed system of sewage disposal for the easterly part of Hull, having its outlet into the sea near Gun Rock. The Board replied as follows: —

FEB. 2, 1892.

The general location of the sewers and of the outfall is probably as satisfactory as any that is feasible to adopt. In other respects the plans are less satisfactory. The sewer in Atlantic Avenue east of Gun Rock Avenue is necessarily placed at a low level and with a very flat grade, and if in addition to these disadvantages the sewage is to be backed up in this sewer half of the time by the tide, as it will be by the proposed plan, deposits will form which would not be removed by the ordinary flow of the sewage, and the sewer would become unsanitary.

The Board advises that, instead of having the sewage backed up in the sewer by the tide, it should be stored in a tank or reser-

voir, built near the outlet, and that a connection as large as the sewer itself should be made from Strait's Pond to this sewer at its upper end. The storage tank should be so large that the sewage under ordinary circumstances would not back up into the sewers. It should have its bottom six inches or a foot above low tide, and should have a tide gate at its outlet, to prevent the entrance of sea water. It may also be desirable to place in the tank some screens having a large area, so that they will not readily be clogged, to prevent the coarse substances in the sewage from being discharged at the outlet.

A connection with Strait's Pond can be utilized to keep the sewer clean in several ways. The easiest way, if it proves efficient, would be to turn the water into the sewer from the pond at low tide, and let it run through to the ocean for an hour or two. If this should not produce a sufficient current to keep the sewer clean, a stronger current may be produced by damming the sewer at a man-hole long enough to permit the water to back up behind the dam and drain away below it. Then, by suddenly removing the dam, a stronger current will be produced below it, which will extend at least to the next man-hole, where the operation can be repeated.

Another method of cleaning a sewer where a large quantity of water is flowing through it, is to insert a ball, having a diameter somewhat less than that of the sewer, with a rope attached to it, long enough to reach from one man-hole to another; by allowing this ball to move forward with the current and at the same time retarding its motion by the rope, a strong current may be produced past the ball which will sweep everything before it.

A portion or the whole of the cost of building the tank may be offset by reducing the sizes of the sewers. An eight-inch pipe will be sufficiently large in all cases to carry the sewage, and there seems to be no occasion for laying a larger pipe in Atlantic Avenue west of Gun Rock Avenue. For the low-level sewer east of Gun Rock Avenue the larger pipe has the advantage that a stronger flush can be obtained by turning water from Strait's Pond through it, and it may have some advantage in furnishing storage in addition to that furnished by the tank, if the latter is at times surcharged. A twelve-inch pipe will, however, be sufficiently large for all purposes, and if it should be found that a sufficient flush can be obtained through a ten-inch pipe, it may be well to adopt this size.

LENOX. The selectmen of Lenox applied to the Board (Nov. 29, 1892) for its advice relative to the location of

a pumping station for pumping the sewage of the westerly part of the village of Lenox to the easterly slope of the town. The Board made the following reply: —

DEC. 23, 1892.

The State Board of Health has considered your application, dated Nov. 29, 1892, with regard to a pumping station for pumping the sewage from the southerly and westerly slopes of the village into the system of sewers which now conveys the sewage from the main portion of the village to a sewage field in the easterly part of the town.

In view of the absence of suitable filtering material in the southerly and westerly sections of the town, and on account of other local conditions, the Board is of opinion that the best method of disposing of the sewage of these portions of the town is by pumping it into the main system, as you have suggested.

With regard to the location of the pumping station, you have indicated three places, as follows: —

1. Between Hawthorne Street and the boundary line in Stockbridge.
2. At a point in the low land north of West Street.
3. At a point in the northerly part of Stockbridge, nearly one-fourth of a mile south of Hawthorne Street and not far from an old slaughter house.

In either of these locations there is no reason why a properly designed pumping station, with provision for ventilating the tank and all other places from which odor might come into the chimney, should give off offensive odors or be objectionable on sanitary grounds, nor are there any other controlling sanitary reasons why any one of these locations should not be chosen.

The Board is therefore of opinion that, in this case, where the choice of a location depends so much upon the local interests affected and upon economic considerations, the selection may properly be left with the town.

THE MASSACHUSETTS HOSPITAL FOR DIPSOMANIACS AND INEBRIATES AT FOXBOROUGH. The primary action of the Board in reply to the application of the trustees of this institution is published in the last report of the State Board of Health (1891), page 53. New data relative to the level of the millpond below the effluent from the disposal field were presented June 4 and 14, 1892, and on the 27th of June the Board addressed the following communication to the trustees of the institution: —

JUNE 27, 1892.

In a communication to you, dated Dec. 2, 1891, the State Board of Health stated that it did not advise the adoption of the plan of sewage disposal as submitted, believing that the application of sewage to such low land would not only insufficiently purify it, but would be liable to cause a nuisance in the vicinity of the disposal area. The Board also stated that "the proposed plan would probably give satisfactory results if it were feasible to reduce the water level by underdrainage to a sufficient depth below the surface of the ground, but from the contours shown upon the plan and figures presented by your engineer it does not appear that this can be done. To raise the surface of the ground to a sufficient height above the ground water would be very expensive."

In view of these conclusions, the Board suggested, as a substitute for the plan of sewage disposal presented, that the sewage be filtered intermittently upon sandy land at a higher level.

Your engineer has recently presented new figures relating to the level of the water into which the effluent from the disposal field is to flow, and from these it is found to be feasible to reduce the water level in the drain at the outlet by .64 feet when the water in the millpond is at its greatest legal height, and by a larger amount when the water in the millpond is drawn below such height.

The amount of filling required to raise the lower portions of the ground to a plane parallel with the drains and four feet above the high-water level at their outlet would be much less than that required for raising it to a plane the same height above the high-water level formerly reckoned upon; but a considerable part of the material of this low land is poorly adapted for the purification of sewage, and, with the filling proposed, the Board thinks it very doubtful if the disposal of the sewage of the hospital by broad irrigation on this tract will be satisfactory.

On August 12 the trustees requested the advice of the Board in regard to the size of a filtering area, which, in connection with a broad irrigation field, would "make the system of drainage satisfactory." To this application the Board replied as follows: —

AUG. 22, 1892.

The State Board of Health has considered your request with regard to the area of filter bed which would be required to dispose of the sewage of the hospital at Foxborough in connection with a broad irrigation area of four acres.

It is understood that the area used for broad irrigation is to be underdrained and filled so that the surface of the ground will be at

least four feet above the water in the ground during all portions of the year. The letter of your engineer which accompanied your request states that the proposed filter bed is to be five feet deep. With this depth to the top of the underdrains, and these so situated that they will not be submerged by ground water and will have free communication with the air, the Board advises that an area of not less than half an acre be prepared in the beginning. With a filter bed of this area it is not essential that the sand should be screened, provided it will allow water to pass through it as freely as an ordinary mortar sand, with which material the underdrains may be forty feet apart.

On Nov. 2, 1892, a further application was submitted to the Board, in which certain new plans for the disposal of the sewage by intermittent filtration were explained, and the approval of the Board was requested upon them. The Board replied as follows: —

Nov. 14, 1892.

The State Board of Health received a communication from your engineer, dated Nov. 2, 1892, explaining plans which had previously been sent to this office, and stating that you wished a formal approval of the scheme of sewage disposal presented.

The plans show a filter bed having an area of 1.12 acres, which, according to the samples sent to this office, is composed of material well adapted for the filtration of sewage; and the filter bed is at such a level that it is feasible to underdrain it to a depth of six or more feet below its surface. That portion of the sewage which comes from the cottages is to be collected in a flush tank and discharged upon the bed intermittently by means of an automatic siphon, while that which comes from the laundry and boiler house, on account of their lower level, is necessarily conveyed to the filter bed without passing through a flush tank.

The area of the filter bed, the character of the material of which it is composed and the method of bringing sewage to it are satisfactory; but the method of taking care of the sewage after it reaches the margin of the filter bed, and of distributing it over the bed, is not. The bottom of all carriers should be placed higher than the surface of the bed, so that they will empty themselves upon it and not have sewage standing in them. The sewage from the boiler house and laundry, being comparatively small in quantity, cannot be properly distributed over the beds by discharging it over the edge of the carrier, as the sewage will gravitate to the lower ends and there overflow instead of overflowing along the whole length; moreover, if this small quantity of sewage did flow evenly

over the whole length of the carrier, it would not flow far enough out upon a bed of porous material to reach the more distant portions. The sewage discharged from the flush tank would distribute itself better, but at the beginning of a flush there would be a much greater tendency for the sewage to overflow where it enters the carrier, and after the flow slackens it would gravitate as in the other case to the lower end of the carrier and overflow there.

In any case, it is not probable that the comparatively small quantity of sewage to be disposed of will distribute itself over so large a bed by flowing in a thin sheet over the surface of the ground from carriers located on two sides of the bed. It will be better to arrange the bed with carriers which will distribute the sewage over smaller areas with steeper slopes of the surface. Carriers placed higher than a filter bed, and provided with several outlets controlled by gates by which the discharge of sewage can be regulated, supply a system which, if it does not accomplish all that is desired in the beginning, can readily be modified by slight changes to effect a proper distribution of the sewage; while a carrier which has its bottom below the level of a filter bed having only a very slight grade presents a condition which cannot be readily modified if it does not at first distribute the sewage properly, and such carrier or ditches which may lead from it will not drain freely and may become offensive.

The six-inch pipe, shown on the plan as connecting one end of the carrier with a blow-off pipe which leads to a sludge pit, is an undesirable feature. This pipe will in any case drain only one end of the carrier, and, if the carrier is placed at a higher level than the filter bed, as herein recommended, it will be unnecessary, as the whole carrier will drain upon the bed.

Medfield Insane Asylum. The trustees of the Medfield Insane Asylum applied to the Board (Oct. 3, 1892) for its advice relative to a plan of sewage disposal by means of intermittent filtration upon land within the grounds of the asylum. The Board replied as follows: —

Nov. 8, 1892.

The general plan of collecting the sewage and carrying it from the buildings is well arranged, so that only the question of its final disposition needs further consideration.

The plan as submitted shows four filter beds for purifying the sewage, each having an area of about one and one-fourth acres. The sewage coming from the buildings is first to flow into a separating and flush tank, and thence is to be distributed over the beds by means of a system of four-inch pipes laid beneath the surface.

The flush tank is to discharge automatically, and a further automatic arrangement is introduced for discharging the sewage successively upon the different beds.

The test pits which have been dug show that the beds differ much in the character of the material and in its adaptability for filtering sewage. They show bed No. 2 to be of excellent material, and that bed No. 4 has very little area that can be used for the disposal of sewage.

The total area of the beds selected would be sufficient if the material had proved to be of suitable quality, but with the quality shown by the test pits it appears that additional area will be needed, and the Board advises that additional area be selected before expense is incurred upon this area.

NATICK. The sewerage committee of the town of Natick applied to the Board for its advice relative to a plan of sewerage and sewage disposal for that town, the general features being a separate system of pipe sewers, the sewage to be pumped to a filtration area outside the water-shed contributing to the Boston water supply. To this application the Board replied as follows: —

MAY 5, 1892.

The plan which accompanied said application shows a system of pipe sewers for collecting the sewage of the town, and a main sewer running in a north-westerly direction to a pumping station near Lake Cochituate and just south of the Worcester turnpike. From the pumping station the sewage is to be conveyed westerly through an iron force main to a large area of flat, sandy land on the southerly side of the Worcester turnpike, and to be there purified by filtration through the ground. The proposed filtration area is outside of the water-shed which contributes to the Boston water supply, and is just across the turnpike from the area now used for the disposal of the Framingham sewage.

After a careful consideration of other methods for disposing of the sewage of Natick, and an examination by the engineer of the Board of the land through which it is proposed by your plan to filter the sewage, the Board concludes that the method of sewerage and sewage disposal submitted by you is the best one for the town to adopt.

REVERE. The sewerage committee of Revere applied to the Board (Dec. 30, 1891) for its advice relative to a proposed system of sewerage and sewage disposal for the

town of Revere, involving an ocean outlet for the sections known as Beachmont and Crescent Beach, and for the centre of the town an outlet into Sales Creek. It was also proposed to "so design the system that at any time, should the least nuisance be created, the pipes can, by simply extending them, enter the Metropolitan system at Breed's Island or Winthrop, as may be deemed advisable, or the entire sewage of the town can be collected at Ocean Pier, and the outlet extended further out into deep water, whenever the necessity should arise." To this application the Board made the following reply: —

JAN. 18, 1892.

By this plan it is proposed to discharge the sewage of the beaches and the villages north of the beaches by gravity through an outfall sewer discharging near the end of the Ocean Pier, and to dispose of the sewage of the centre of the town by discharging it into Sales Creek at a point about one-third of a mile, measured along the creek, below Winthrop Avenue. The plan also indicates a line for the future extension of the main sewer from the centre of the town with suitable grades to a pumping station near the shore end of the Ocean Pier, and a line showing a route for a force main and sewer to connect with the Metropolitan system in the town of Winthrop, so that, by building these portions which are to be omitted in the beginning, the sewage can, in the future, be pumped into the Metropolitan system; or, by extending the temporary outlet pipe near the pier, it can be pumped out to sea during the early portion of the outgoing tide to a point more distant from the shore.

When the pumping station is built and the main sewer from the town is extended to it, as before indicated, this plan, as far as the pumping station, will be the same in its general features as that reported to the town by the sewerage committee of 1889, with the exception of the main sewer in Ocean Avenue. This sewer by the present plan is placed at a higher level than in the former one, so that it may discharge by gravity; and as a consequence it cannot be extended much if any north of Bath Avenue without coming too near the surface of the ground. When the pumping station is constructed, this sewer should be lowered or duplicated so as to take the sewage from the beach districts as far as a point beyond Revere Street, as was formerly proposed. By making this change, in addition to the others already mentioned, the completed system will provide for substantially the same territory as the system proposed by the committee of 1889.

The principal saving which will result from the adoption of the temporary plan for the discharge of the sewage by gravity will be the cost of operating the pumping station, and a reduction in the amount paid for interest and sinking fund upon those portions of the work which will not be built in the beginning, viz., the pumping station, the low-level receiving basin, one thousand feet of discharge pipe extending from the now proposed temporary outlet to the formerly proposed permanent outlet, and the portion of the main sewer from the centre of the town, located between the Boston & Maine Railroad and the proposed pumping station.

As a partial offset to this saving, those parts of the present plan designed for temporary use will either become valueless when the works are completed, or will be worth much less than their first cost. These comprise the temporary receiving basin, the temporary sewer leading to the Sales Creek outlet, and some other sewers which will require duplication or reconstruction in the future.

It is doubtful if the town will in the end save anything by adopting a temporary gravity system to be afterwards changed into a pumping station; and, even if there should be some saving, it will, in the opinion of the Board, be more than offset by the much less favorable outlets for the sewage which are now proposed.

Notwithstanding these opinions as to how the interests of the town will be best served, the Board recognizes that a system of sewerage is urgently needed; and if in the judgment of your citizens it is not practicable at the present time to incur the larger expenditure required for the more complete system, the Board is of opinion that it is permissible to construct for present use the system indicated upon the plan submitted, and to use the outlets shown upon said plan for the next five years, or for a shorter period if any nuisance should be created in the mean time.

SHELBURNE. The selectmen of the town of Shelburne applied to the State Board of Health (Oct. 27, 1892) for its advice relative to a partial system of sewerage for that town, having an outlet below the dam at Shelburne Falls, and below all the mills. The Board replied as follows: —

DEC. 1, 1892.

The State Board of Health has considered your application, dated Oct. 27, 1892, and the plans which accompanied it, relating to a partial system of sewerage for your town. This system provides for the discharge of the sewage into the Deerfield River below all mills. The Board is of opinion that for the present this method of sewage disposal is permissible.

SOUTHBRIDGE. The sewer committee of Southbridge, conjointly with the selectmen, applied to the State Board of Health (Dec. 7, 1891) for its advice relative to the propriety of discharging the sewage of the principal village temporarily into the millpond of the Optical Company, below the village. The Board replied as follows: —

FEB. 3, 1892.

The Board is of opinion that the sewage from the proposed system should not be discharged, even temporarily, into the Optical Company's millpond, and advises that a more extended investigation of the subject should be made. This investigation should comprise a survey and estimate of the cost of a main sewer of proper size for conveying the sewage of the whole town, extending to the river below the works of the Southbridge Printing Company at Saundersdale. It should also comprise an examination as to the area and character of such land as may be found available for the filtration of sewage in the vicinity of Southbridge. These estimates should be subdivided so as to give the cost of the portion of the main sewer extending from the outlet now proposed to one at the lower end of the tail-race of the lower millpond of the Optical Company, of a second portion extending from this point to a point just below the dam of the Southbridge Printing Company, and of a third portion extending to the river below Saundersdale.

With this information before the Board, it can decide whether the sewage may temporarily be turned into the river, and at what place.

On June 27, 1892, the selectmen presented another application, urging the millpond as a location for the temporary outlet of sewage discharge, together with plans for extension of the outlet at a future time further down the river, or to a filtration area.

A letter was also presented from the Optical Company, waiving objections to a temporary discharge into the millpond.

To this application the Board replied as follows: —

JUNE 27, 1892.

The State Board of Health has considered your application of June 18, 1892, accompanied by the following plans and documents: first, a plan of the central portion of Southbridge, showing proposed sewers having an aggregate length of about 1.13 miles, and

an outlet into the Lensdale Pond above the lower mill of the American Optical Company; second, a plan showing methods by which this sewer can be extended to outlets further down the river, or to an area bounded by Main Street, the canal of the Southbridge Printing Company and the river, where the sewage can be purified by filtration through land; third, a report of A. C. Moore, C.E., showing the cost of extending the sewer to the different outlets; fourth, a letter from Mr. George W. Wells, president and treasurer of the American Optical Company, waiving all objections to the discharge of sewage into the millpond for the present; fifth, a copy of the vote of the town, appropriating money for the construction of the sewer.

The Board, in its communication upon this subject dated Feb. 3, 1892, expressed the opinion that the sewage from the proposed system should not be discharged, even temporarily, into the Optical Company's millpond, and advised the more extended investigations which you have made. It is still of opinion that it is desirable for the town to adopt in the beginning a better outlet than that now proposed; but in view of your representations as to the urgent need of sewerage for the small part of the town which is to be provided for in the beginning, and to the impracticability of obtaining a larger appropriation at the present time, also to the further fact, as shown by surveys, that the sewer can be extended to a better outlet when necessary, the Board is of opinion that the proposed outlet is temporarily permissible.

WAKEFIELD. The sewerage committee of Wakefield applied to the Board (Jan. 4, 1892) for its advice relative to a plan of sewage disposal by filtration upon a tract of land in the easterly part of the town. At the same time alternative plans were presented for disposal, (1) upon a tract of land in the northerly part of the town, (2) into the Saugus River, (3) into the North Metropolitan sewer at its nearest point in Melrose. To this application the Board made the following reply: —

FEB. 20, 1892.

Your application, dated Jan. 4, 1892, asks for the advice of the Board with regard to a plan for the disposal of the sewage of Wakefield, which is that reported to the town by a sewerage committee in 1889, and provides for the disposal of the sewage upon land situated upon the west side of Farm Street in Wakefield. Advice is also asked upon alternative plans as follows: —

1. Disposal upon a tract of land in the northerly part of the

town, situated east of Danvers Branch Railroad and near the Saugus River.

2. Disposal into the Saugus River below Howlett's dam in North Saugus.

3. Disposal into the North Metropolitan sewer at its nearest practicable point in Melrose.

These four plans include but three general methods of disposal, which may be considered in the following order: —

1. Disposal by discharging crude sewage into the Saugus River.

2. Disposal into the North Metropolitan system.

3. Disposal by filtration through land, permitting the purified effluent to flow into the Saugus River or some of its tributaries.

The quantity of sewage produced in Wakefield is so great that, if it were discharged into the Saugus River without purification, it would before long, if not in the beginning, pollute the stream to such an extent that it would become offensive to those living near it. This method of disposing of the sewage, therefore, cannot be advised.

The plan for the disposal of the sewage into the North Metropolitan system is particularly well adapted for the village of Greenwood, from which it would be difficult to dispose of the sewage by any independent system, or in connection with the sewage of other parts of the town. For the main village of Wakefield a connection with the North Metropolitan system could not probably be made without pumping the sewage; and the cost of pumping, together with the annual charge which would be made for a connection with the Metropolitan system, even if permission can be obtained to connect with it, would probably make this method of disposal cost more than an independent system for purifying the sewage upon land, provided a suitable filtration area can be found not too far from the town. There may be reasons, however, which will warrant a connection with the Metropolitan system, such as, for instance, the inability to find an area of sufficient size for the disposal of the sewage in the future, which will not interfere with the growth of the town or pollute future sources of water supply.

By filtering the sewage intermittently through porous land in limited quantities per acre, where the surface of the land stands five feet or more above the ground water, the sewage can be so thoroughly purified that its discharge into even a small stream will not be objectionable; and where a sufficient area of land is available, and proper care is taken to distribute the sewage evenly and otherwise to maintain the works in good condition, a sewage field will not be offensive to those living in its neighborhood.

The plan reported by the sewerage committee of the town in 1889, which is the main plan submitted, has the advantage that it brings the sewage to the filtration area by gravity; but it is defective in that it does not provide for the disposal of the sewage of about one-fifth of the buildings shown upon the plan, nor for the sewage of the rattan factory, and the main features of the plan are such that it would be necessary to reconstruct the main lines of the system in order to include the buildings omitted. In addition to these principal objections to the plan, there are still others, occasioned by the high levels of the outlet, such as the great length of sewer in private property and the insufficient depth of the sewers in some of the low lands, principally in the flat land north of Crystal Lake. All of these objections would be met to a large extent if the upper ten feet of the gravelly land near Farm Street were to be excavated and spread upon the adjacent meadow, and the main sewer lowered a corresponding amount.

If the modified gravity plan here suggested does not prove on investigation to be the best one to adopt, it will probably be necessary to pump all the sewage; in which case the main sewer can be placed in the lowest land and sewage can be taken from all buildings in this portion of the town. If the sewage is to be pumped, the best place for purifying it is by no means evident from the information now before the Board. The land near Farm Street, which it was proposed to use in connection with the gravity plan as submitted, is of excellent quality, but rather limited in extent. It contains two small houses and a school-house, and is not very far from settled portions of the town. It has the advantage of being more accessible than any other disposal area, and if the modified gravity plan above suggested should be adopted, the available area could be increased to thirty or forty acres, which would be sufficient for all requirements for many years in the future.

The disposal area in the northerly part of the town, mentioned as an alternative, is more uneven than the area near Farm Street, and the material is not as porous, although it has sufficient porosity to permit the disposal of sewage in a satisfactory manner. This area has the advantage that it is further from settled portions of the town than the one near Farm Street.

The Board advises the town to have the whole subject of its sewerage and sewage disposal reinvestigated, with a view either to purifying its sewage by filtration at some place where sufficient land can be obtained to meet the requirements for the next thirty or forty years, or to pumping it into the Metropolitan system. These examinations should also include a system for the village of

Greenwood, which can probably be taken care of better by the Metropolitan system than in any other way.

On August 29, the committee submitted to the Board plans for the sewerage and sewage disposal of the town, that of the principal village to be treated by filtration upon land south of the town almshouse in the easterly part of the town, and that of the two villages in the southerly part of the town to be discharged into the Metropolitan sewer. To this application the Board replied as follows: —

Oct. 7, 1892.

In response to your application of Aug. 29, 1892, accompanied by a plan for the sewerage of your town, and asking the advice of the State Board of Health in regard thereto, the Board has caused investigations to be made, has carefully considered the plan submitted and herewith presents its reply.

It is proposed by this plan to collect the sewage of all parts of the town by means of a system of pipe sewers from which storm water is to be excluded, and these sewers are arranged in two independent systems, one for the southerly part of the town, including the villages of Greenwood and Boyntonville, and the other for the main village. The one for the southerly part of the town is planned to connect with the Melrose sewers and through them with the Metropolitan system. The other provides for the disposal of the sewage by intermittent filtration upon sandy land in the vicinity of the town almshouse.

The disposal of the sewage of the southerly part of the town into the Metropolitan system is the best method that can be adopted for this district, provided the consent of the proper authorities can be obtained.

The disposal of the sewage of the main village by intermittent filtration through a sufficient area of porous land is also the best available method of disposing of the sewage of this portion of the town.

With regard to the best place for filtering the sewage, your engineer has shown in his report that the proposed disposal area has a decided advantage, in regard both to the cost of reaching it with the sewage and to the cost of maintenance, over any other available area. The character of the land at this place is also of excellent quality for filtration, so that on the whole these advantages may be said to outweigh the disadvantage that the tract contains two small houses and a school-house, and is not very far from settled portions of the town.

With regard to the amount of land required in the beginning for purifying the sewage, much will depend upon the extent to which ground water is excluded from the sewers. In several instances towns have had a much larger amount of sewage to pump or purify than was expected, owing to the entrance of ground water, notwithstanding all precautions taken to make the joints of the pipe sewers water-tight. The only practicable remedy for this trouble, so far as now known, is to provide underdrains of suitable size to take away the ground water of those districts where the sewers are below the ground-water level, and discharge this water into such streams as are most available. Even if the amount of ground water is restricted as far as practicable, the Board is of opinion that not less than six acres should be prepared for filtering the sewage in the beginning, with provision for increase in a few years.

The best method of preparing the filtration area can hardly be determined without a careful, detailed study. If beds are prepared by filling upon the adjacent swamp, their surface should be raised not less than six feet above the present water level in the brook, and the underdrains should be placed near enough together so that when the sewage is applied to the beds the water in the ground will always remain drained down to at least five feet below the surface. Beds prepared by excavating the higher land should have their surface left eight or preferably ten feet higher than the present level of the brook, and would not need as much underdrainage as beds prepared by filling upon the swamp, and would more efficiently purify the sewage. If the town should acquire a sufficient amount of land, a portion or the whole of the filter beds might be prepared at a smaller cost upon the top of the flat land than by the plan of excavating and filling, as proposed by the plan submitted. As before stated, however, the best method to adopt will require a detailed study, which should precede actual construction, and the Board will give further advice as to the preparation of the disposal area at such time if so desired.

The present plan for collecting the sewage and bringing it to the filtration area appears to have been carefully designed, and to be comprehensive and well adapted to the wants of the town.

WESTBOROUGH. The selectmen of Westborough applied to the Board (April 16) for its advice relative to a plan of sewage disposal for that town, upon land within the town, the location having already been approved by the State Board after a public hearing held July 7, 1891, under the provisions of chapter 124 of the Acts of 1890. The plan

was unsatisfactory, and it was expected that the results of new investigations by the engineer of the town, together with a new plan, would be submitted. No plan having been received by the Board, the following reply was made: —

Nov. 3, 1892.

The plan made by your engineer and referred to in your application shows twelve filter beds having a total area of three acres, located just beyond the end of the main sewer as now built, and upon the northerly half of the peninsula of upland taken by the town of Westborough for the purpose of sewage disposal.

From an examination of the pits dug at the site of these beds it was found that the material in all except the southerly tier of beds is so fine that it would be impracticable to filter more than a very small quantity of sewage through it, so that a change of plan is necessary; moreover, the large amount of ground water (125,000 gallons per day on May 14, 1892) in addition to the sewage makes it necessary that a larger filtration area should be prepared than would be needed if the ground water had been kept out of the sewers.

These facts as to the inadequacy of the plan submitted were communicated to your engineer as soon as practicable, and the long delay in making this official reply has been due to the fact that it was expected that the results of further investigations by your engineer, and a new plan, would be submitted. No such plan having been received, however, the Board now informs you as to the inadequacy of the original plan, and advises that the town should prepare filter beds having a total area of not less than five acres for the disposal of its sewage. These beds should consist of sufficiently porous material to properly filter the sewage, and if of such a character or so situated that the ground-water level will not remain at least five feet below the surface of the beds, they should be efficiently underdrained.

The most economical method of preparing beds such as are here described is a matter which requires investigation. If a portion of your land can be found where there are two or three feet of porous material above the level of the water in the Assabet River, the required height of filter bed can be obtained by filling gravel upon this portion after the loam or any other layer of very fine material which may be found has been stripped from it. If such land as is here described cannot be found, it may then be necessary to prepare beds by cutting down some of the higher gravelly land to the proper level and filling the excavated material upon the low land, both the excavated and filled areas being used for

filtration. The character of the material lying on the easterly side of a narrow swamp and also easterly from the tract belonging to the town appears to be of suitable quality for the construction of filter beds by the last-described method.

WESTFIELD. The selectmen of Westfield applied to the Board (March 28, 1892) for its advice upon a system of sewerage for that part of the town lying north of the Westfield River, as indicated upon a plan submitted, and having an outlet into the river below the dam. To this application the Board replied as follows: —

APRIL 25, 1892.

The plan provides for an outlet into the river, opposite the culvert under the Boston & Albany Railroad, half a mile below the dam across the river. This location of the outlet appears to be the most satisfactory one available.

The plan also shows that the main sewer at the corner of Union and Grant streets has been placed at as low a level as is consistent with a suitable inclination of the sewer from this point to the river. The Board believes this to be an important feature, which should be adhered to when the sewers are constructed, as it will permit the extension of the system further to the north of Union Street when streets are built upon the flat land at this place.

Taking the plan as a whole, the Board is of opinion that it furnishes a satisfactory solution of the problem of disposing of the sewage of this portion of the town.

WINTHROP. The sewerage committee of Winthrop applied to the Board (Feb. 24, 1892) for its advice relative to a plan of sewerage for a low and thickly settled part of the town not embraced in its former plan of sewerage adopted in 1889. To this application the Board replied as follows: —

MARCH 9, 1892.

The State Board of Health has considered your request for its approval of a system of sewerage for a small section of the town, as shown upon the plan accompanying said request, said system to be permanently connected with the Metropolitan sewer as soon as it is put in operation, but in the mean time to have a temporary outlet into the low-water channel of Belle Isle Inlet at Main Street; and hereby approves the system of sewerage and sewage disposal submitted, with its permanent outlet into the Metropolitan sewer. It also, in view of the urgent need of sewerage facilities at the present time, approves of the use of the temporary outlet into

the low-water channel of Belle Isle Inlet until such time as the Metropolitan sewer is put in operation.

On Aug. 30, 1892, the sewerage committee submitted a plan of sewers for those parts of the town not already provided for, and designed to discharge into the Metropolitan system. To this application the Board replied as follows: —

Sept. 12, 1892.

The plan submitted by you Aug. 30, 1892, under the provisions of chapter 260 of the Acts of 1888, showing in full lines a system of sewerage for those portions of the town not already provided with sewers, and providing for the discharge of the sewage into the Metropolitan system, is hereby approved by the State Board of Health. The plan is entitled "Plan showing system of sewerage for the town of Winthrop," is dated "April, 1892," and is signed by "David Floyd, 2d, Henry A. Root and Wm. B. Floyd, sewer committee."

Pollution of Streams.

Millbury. The board of health of Millbury addressed a communication to the State Board of Health (Dec. 8, 1891) containing the following inquiries: —

"1. Whether, in your opinion, the city of Worcester has, according to the intent of the law, complied with the statute requiring her to rid the river of its sewage.

"2. Whether the results attained are satisfactory to your honorable body.

"3. Whether, in your opinion, the plans adopted by the city are adequate to accomplish the result so much desired, and so important to this community.

"4. Whether, in your opinion, the city is acting with reasonable promptness and efficiency in the matter.

"5. Whether, from the facts in the case known to you, there is reason to believe that in the near future the city will efficiently treat *all of its sewage* in a manner that will be satisfactory to you, and give this community the relief it seeks."

To these inquiries the Board made the following reply: —

March 1, 1892.

The answer to these questions, so far as they come within the province of this Board, may be presented in a general considera-

tion of the condition of the river at the present time where it enters your town, as compared with its condition in 1886, when the act to establish a system of sewage disposal for the city of Worcester was passed.

The population of Worcester from 1885 to 1890 increased twenty-four per cent., and the increase from 1886 to 1891 would not be materially different. The sewage of the city of Worcester is turned into Mill Brook, and mingles with the natural water of the brook. A portion of this mingled sewage and brook water is then diverted to the disposal works. Judging from the flow which may naturally be expected in a brook draining an area of the size drained by Mill Brook, and from such information as is now available to the Board with regard to the amount of sewage treated at the disposal works, it seems probable that the percentage of sewage treated will no more than offset the increase in population from 1886 to 1891. If we take into account that the total length of sewers in Worcester has increased much faster than the population, and that all of the organic matter is not removed from the sewage by the process of precipitation, there can be no doubt that the amount of organic matter discharged into the river from Worcester is greater at the present time than it was in 1886.

The examination of the water of the river, where it enters the town of Millbury, made by the Board, indicates that it is seriously and offensively polluted by sewage, and by comparing the analyses of the water, which have been made monthly by the Board since June, 1887, it appears that the pollution of the river was no less during the past year than it was in the years before the Worcester sewage disposal works were put in operation.

EXAMINATION OF WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The systematic examination of the water supplies of the State was begun June 1, 1887, and has been continued up to the present time. The results for the years previous to 1892 have been published in three reports, as follows: June 1, 1887, to May 31, 1889, in the Special Report of the Board upon the Examination of Water Supplies (1890); June 1, 1889, to Dec 31, 1890, in the Twenty-second Annual Report of the Board for the year 1890; for the year 1891, in the Twenty-third Annual Report of the Board for that year. The present, Twenty-fourth Annual, report contains the results for the year 1892.

The first of these reports contained a description of each of the water supplies in the State existing at the date of that report. The later reports have described only new works and changes in existing works.

An alphabetical arrangement by towns has been adopted in this, as in previous reports. Sources of water supply are tabulated under the name of the town supplied, other waters under the name of the town in which they are situated. The analyses of water from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Examination of Rivers."

The chemical examinations in this report were made in the same manner as heretofore, and are presented in the tables in the same form as in the last two reports, except that during the latter part of 1892 the amount of iron in waters has also been determined.

All surface water and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color and residue on evaporation. Occasionally these determinations are also made on the unfiltered water, the results in such cases being specially indicated. In the case of certain ground waters which, although clear when drawn, contain iron in a soluble form, and subsequently, upon exposure to the air, become turbid with suspended particles of iron rust owing to the oxidation of the iron, the determinations of the solid residue and iron are made upon the unfiltered water. The color is observed from time to time, to show the changes undergone on standing.

The color of water is expressed by numbers which increase with the amount of color. The standard used is nesslerized ammonia, as described on page 531 of the Special Report upon the Examination of Water Supplies, 1890. Boston water, as drawn from a tap at the Institute of Technology, had an average color for five years of 0.40. Other water supplies in the State have an average color of from 0 to 1.45.

In the microscopical examination of water there has been no change in the method employed since Nov. 6, 1890. This method was fully described in the Twenty-third Annual Report of the Board for the year 1891 (pages 395–421). Before Nov. 6, 1890, the methods employed were less perfect, so that a smaller proportion of the total number of organisms present in the water were separated from it and observed under the microscope; and, before drawing conclusions from a comparison of the microscopical examinations of waters made before and after this date, the explanatory note on page 70 of the Annual Report for 1890 should be read.

To indicate the amount of the so-called *Zoöglœa* observed, the number of individual masses is not counted, but an area equal to 2,500 square microns, or .0025 square millimeters, has been adopted as an arbitrary unit.

In publishing the results of the microscopical examinations the same system is followed as last year. The Plants observed are classified in four groups, viz.: Diatomaceæ, Cyanophyceæ, Algæ and Fungi. The Animals observed are grouped as Rhizopoda, Infusoria, Vermes and Crustacea.

The names of the different genera in each group are given with the numbers of each per cubic centimeter, except that, to avoid making the tables excessively long, they are omitted when present only in very small numbers. It is not feasible to make with regard to omissions a single rule which will apply to all cases, because it is desirable to include smaller numbers of animals than of plants, and of the larger animals than of animals generally. Moreover, there are exceptional cases in which it is desirable to indicate the presence of even very small numbers of the more important plants or animals. Two general rules, however, have been adopted in printing the results, namely: —

1. All genera of Plants are included in which the total number observed in twelve months amounts to 6 or more per cubic centimeter, or in other words averages as much as 0.5 per month.

2. All genera of Animals are included in which the total number observed in 12 months amounts to 1.5 or more per cubic centimeter.

The larger microscopic animals, such as some of the Crustacea, are included even when present only in very small numbers.

Fractions are generally omitted from the table, the nearest whole number of organisms per cubic centimeter being given. Where the total number of organisms observed is 0.5 or less, the fact that the organism was present is usually indicated by the abbreviation "pr.," but in the case of the larger organisms very small fractions are given.

EXAMINATION OF WATER SUPPLIES.

Water Supply of Abington and Rockland.

Chemical Examination of Water from Big Sandy Pond, Pembroke.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.	1892.													
8612	Mar. 14	Mar. 15	Slight.	Slight, white.	0.10	4.30	-	.0000	.0200	.0150	.0050	.59	.0090	.0000	0.5

Odor, disagreeable. —— The sample was collected from the pump well at the pumping station.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 154; *Cyclotella*, 162; *Diatoma*, 1; *Fragilaria*, 19; *Melosira*, 2; *Navicula*, 1; *Stephanodiscus*, 3; *Synedra*, 114; *Tabellaria*, 76. Algæ, *Chlorococcus*, 3; *Staurastrum*, 1. Infusoria, *Dinobryon*, 2; *Dinobryon cases*, 6. Crustacea, *Crustacea remains*, .01. Miscellaneous, *Zoöglœa*, 32. Total, 576.

Water Supply of Amesbury.—Powow Hill Water Company.

Chemical Examination of Water from Tubular Wells supplying an Open Basin.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.	1892.											
8863	May 5	May 6	V. slight.	Slight.	0.00	6.05	.0026	.0086* .0076	.50	.1700	.0003	2.2	-
9232	Aug. 10	Aug. 11	Distinct, milky.	V. slight.	0.02	7.25	.0018	.0000	.52	-	.0001	3.0	.0250

Odor of No. 8863, distinctly vegetable and grassy; of No. 9232, faintly disagreeable. In the latter case the odor disappears on heating. —— The first sample was collected from the open basin, in the bottom of which fourteen tubular wells have been driven; the second sample from a faucet in the pumping station while pumping.

* This determination was made upon the water before it was filtered through filter-paper.

Microscopical Examination.

No. 8863. Diatomaceæ, *Melosira*, 1; *Synedra*, 1. Cyanophyceæ, *Oscillaria*, 1. Algæ, *Scenedesmus*, 3. Miscellaneous, *Zoöglœa*, 11. Total, 17.

No. 9232. Diatomaceæ, *Synedra*, 38. Algæ, *Zoöspores*, 238. Miscellaneous, *Zoöglœa*, 120. Total, 396.

AMESBURY.

Chemical Examination of Water from Thirty-six Tubular Wells used as a Supplementary Source of Supply.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9233	Aug. 10	Aug. 11	None.	None.	0.0	19.40	.0010	.0020	1.02	-	.0002	12.5	.0150

Odor, none.——The sample was collected from a faucet in a pumping station near the wells. This system of wells was completed in 1886, but proved inadequate for the supply of the town and was abandoned for the time. It became necessary to use it again as a supplementary source during the summer of 1892.

Microscopical Examination.

Algæ, *Zoöspores*, 2.

Water Supply of Andover.

Chemical Examination of Water from Haggett's Pond, Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8645	Mar. 21	Mar. 23	V.slight.	V.slight.	0.08	2.75	0.70	.0010	.0092	-	-	.37	.0070	.0000	1.6
8835	May 2	May 3	Slight.	Slight.	0.10	3.10	1.15	.0000	.0132	.0116	.0016	.30	.0030	.0000	1.1
8926	May 24	May 25	Distinct.	Cons.	0.10	3.35	1.00	.0000	.0298	.0258	.0040	.33	.0060	.0000	1.3
9034	June 27	June 28	Slight.	Slight.	0.08	3.40	1.25	.0002	.0218	.0152	.0066	.34	.0030	.0000	1.3
9150	July 26	July 27	V.slight.	V.slight.	0.04	3.80	1.30	.0000	.0144	.0110	.0034	.29	.0040	.0000	1.6
9285	Aug. 22	Aug. 22	Slight.	Slight.	0.02	2.85	0.90	.0006	.0140	.0106	.0034	.37	.0000	.0001	1.1
9456	Sept. 27	Sept. 29	Slight.	Slight.	0.08	3.10	0.95	.0000	.0140	.0136	.0004	.35	.0030	.0000	1.3
9571	Oct. 25	Oct. 26	V.slight.	V.slight.	0.05	3.15	1.00	.0008	.0138	.0126	.0012	.31	.0150	.0000	1.3
9700	Nov. 21	Nov. 22	V.slight.	V.slight.	0.05	3.10	0.80	.0002	.0186	.0160	.0026	.36	.0000	.0000	1.5
9822	Dec. 20	Dec. 21	Slight.	Slight.	0.01	3.40	1.15	.0000	.0180	.0160	.0020	.39	.0100	.0000	1.4
Av.	....	....	....	....	0.06	3.20	1.02	.0003	.0167	.0147	.0028	.34	.0051	.0000	1.3

Odor, generally faintly vegetable or none; in May the odors were much stronger, and on heating the water became disagreeable and oily.——Nos. 8645, 8835 and 9456 were collected from a faucet in the pumping station; the remaining samples directly from the pond.

ANDOVER.

Microscopical Examination of Water from Haggett's Pond, Andover.

[Number of organisms per cubic centimeter.]

	1892.									
	Mar.	May.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	4	25	29	28	24	29	27	22	22
Number of sample,	8645	8835	8926	9034	9150	9285	9456	9571	9700	9822
PLANTS.										
Diatomaceæ,	**73**	**118**	**972**	**47**	**14**	**27**	**3**	**21**	**113**	**91**
Asterionella,	4	1	892	4	0	0	0	0	pr.	0
Cyclotella,	20	4	6	17	1	2	1	15	66	82
Melosira,	0	44	3	0	0	0	0	3	32	4
Navicula,	0	0	pr.	3	pr.	1	pr.	1	1	pr.
Synedra,	47	50	58	2	5	22	1	2	5	5
Tabellaria,	2	19	13	21	8	2	1	pr.	9	0
Cyanophyceæ,	**0**	**0**	**0**	**90**	**30**	**30**	**0**	**10**	**0**	**0**
Anabæna,	0	0	0	37	1	15	0	2	0	0
Chroöcoccus,	0	0	0	46	5	7	0	8	0	0
Microcystis,	0	0	0	7	24	8	0	0	0	0
Algæ,	**0**	**2**	**3**	**23**	**96**	**124**	**7**	**2**	**3**	**7**
Chlorococcus,	0	0	0	10	96	114	0	0	0	0
Protococcus,	0	0	0	4	0	0	0	0	0	7
Raphidium,	0	0	3	13	0	9	7	2	1	0
Scenedesmus,	pr.	2	pr.	0	0	1	0	0	2	0
ANIMALS.										
Rhizopoda. Actinophrys,	**0**	**0**	pr.	pr.	**0**	**0**	**0**	pr.	**0**	pr.
Infusoria,	**16**	**2,002**	**101**	**0**	**1**	**1**	**0**	**1**	**0**	**12**
Dinobryon,	0	106	0	0	0	0	0	0	0	5
Dinobryon cases,	16	1,896	100	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	7
Peridinium,	0	pr.	pr.	pr.	1	1	pr.	1	0	pr.
Miscellaneous. Zoöglœa,	**0**	**0**	**5**	**14**	**0**	**40**	**0**	**5**	**14**	**0**
TOTAL,	89	2,122	1,080	178	141	222	10	39	130	110

WATER SUPPLY OF ARLINGTON.

A twenty-inch pipe was laid along the shore of the storage reservoir in 1892, to connect with North Brook above the point where it enters the reservoir. Water can now be taken directly from the brook into the filter-gallery, making it unnecessary to use reservoir water directly except at times when the yield of the brook and filter-gallery combined is too small for the use of the town.

ARLINGTON.

Chemical Examination of Water from the Arlington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8533	Feb. 18	Feb. 19	V. slight.	V. slight.	0.55	8.40	2.25	.0042	.0150	.0136	.0014	.63	.1050	.0000	2.9
8534	Feb. 18	Feb. 19	Slight.	V. slight	0.55	7.40	2.25	.0036	.0208	.0172	.0036	.61	.0850	.0002	2.5
8535	Feb. 18	Feb. 19	Distinct, milky.	V. slight.	0.40	7.15	1.75	.0222	.0112	.0098	.0014	.66	.0950	.0000	2.7

Odor, vegetable; stronger in 8534 than in the others.—— No. 8533 was collected from North Brook, above the point where it enters the storage reservoir; No. 8534, from the storage reservoir; No. 8535, from the filter-gallery on the shore of the storage reservoir.

Microscopical Examination of Water from the Arlington Water Works.

[Number of organisms per cubic centimeter.]

	1892. February.	1892. February.	1892. February.
Day of examination,	20	20	20
Number of sample,	8533	8534	8535
PLANTS.			
Diatomaceæ,	165	47	2
Cocconema,	1	0	0
Cyclotella,	pr.	1	0
Meridion,	14	0	0
Navicula,	6	0	0
Synedra,	144	46	2
Algæ. Zoöspores,	0	12	0
Fungi. Crenothrix,	0	12	0
ANIMALS.			
Rhizopoda. Actinophrys,	0	1	0
Infusoria,	1	447	0
Ciliated infusorian,	0	444	pr.
Peridinium,	1	3	0
Miscellaneous. Zoöglœa,	8	4	118
TOTAL,	174	523	120

ARLINGTON.

Chemical Examination of Water from Tubular Test Wells at East Lexington.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8609	Mar. 12	Mar. 14	Decided, clayey.	Heavy, rusty.	0.10	7.60	.0024	.0004	.31	.0070	.0002	4.0	–
8610	Mar. 12	Mar. 14	Slight, clayey.	Slight, earthy.	0.02	5.85	.0006	.0000	.27	.0090	.0001	2.3	–
9738	Nov. 28	Nov. 29	Slight.	V. slight.	0.20	7.65	.0048	.0148	.46	.0000	.0000	4.1	.0400
9739	Nov. 28	Nov. 29	Slight, milky.	Slight.	0.25	8.10	.0096	.0082	.45	.0100	.0000	5.0	.0850
9752	Dec. 2	Dec. 3	None.	None.	*0.10	8.05	.0048	.0086	.51	.0000	.0000	4.8	.0550
9753	Dec. 3	Dec. 5	None.	None.	*0.08	8.30	.0074	.0092	.51	.0000	.0000	4.8	.0425
9756	Dec. 3	Dec. 5	None.	V. slight, sand.	*0.08	8.05	.0106	.0100	.50	.0070	.0001	4.1	.0500

Odor of the first sample, faintly vegetable and unpleasant, becoming stronger on heating; of the second sample, faintly earthy, disappearing on heating; of the third sample, none, becoming vegetable and very disagreeable on heating; of all others, none.——The first sample was collected from a tubular well seventeen feet deep, sunk in the Great Meadows several hundred feet from the upland; the second sample from a tubular well in Reed's Meadow near North Brook. All the remaining samples were collected from a system of seventeen tubular wells, driven in a line running north-easterly along the south-easterly edge of the Great Meadows from a point a short distance north of the East Lexington station on the Boston & Maine Railroad. Some of the wells are in the meadow and some in the upland, but in either case only a few feet from the edge of the meadow. They are numbered consecutively from 1 to 17, beginning at the easterly end of the line. Sample No. 9738 was collected at 8 A.M., November 28, from the first ten wells after pumping continuously for about forty hours. Water had been pumped from the wells on a previous occasion for six days, but a week intervened between the first and second pumping. No. 9739 was collected at 4 P.M., November 28, while pumping from the first fifteen wells. No. 9752 was collected at 10 A.M., while pumping from the first nine wells. No. 9753 was collected at 11 A.M., December 3, while pumping from the first twelve wells. No. 9756 was collected at 4 P.M., December 3, while pumping from the five wells nearest the railroad. The depths of the wells varied, the shortest being fourteen feet, the longest forty-nine feet and the average depth twenty-three feet. The wells were driven during an investigation for an additional water supply for Arlington.

The suction pipe of the pump not only connected with the wells, but also with a pipe communicating with the water standing in the Great Meadows. It is probable that some of the samples contained a small proportion of meadow water.

* The color of each of these samples was determined again after standing five days with the following results: Color of Nos. 9752 and 9753, unchanged; of No. 9756, 0.15.

ARLINGTON.

Microscopical Examination of Water from Tubular Test Wells at East Lexington.

[Number of organisms per cubic centimeter.]

	1892.						
	Mar.	Mar.	Nov.	Nov.	Dec.	Dec.	Dec.
Day of examination,	16	16	30	30	3	5	6
Number of sample,	8609	8610	9738	9739	9752	9753	9756
PLANTS.							
Diatomaceæ,	**0**	**0**	**2**	**0**	**0**	**1**	**0**
Asterionella,	0	0	2	0	0	0	0
Tabellaria,	0	0	0	0	0	1	0
Algæ,	**0**	**0**	**4**	**0**	**0**	**0**	**0**
Closterium,	0	0	2	0	0	0	0
Eudorina,	0	0	1	0	0	0	0
Protococcus,	0	0	2	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**1**	**0**	**0**	**4**	**0**
ANIMALS.							
Infusoria,	**0**	**0**	**77**	**0**	**48**	**15**	**0**
Dinobryon,	0	0	4	0	0	0	0
Pandorina,	0	0	9	0	2	0	0
Peridinium,	0	0	60	0	44	15	0
Synura,	0	0	3	0	2	0	0
Vermes. Polyarthra,	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**616**	**100**	**0**	**36**	**8**	**24**	**0**
TOTAL,	616	100	85	36	56	44	0

ASHBURNHAM.

Chemical Examination of Water from Upper Naukeag Pond, Ashburnham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8696	Apr. 4	Apr. 4	V. slight.	V. slight.	0.06	3.10	1.25	.0000	.0106	.0064	.0042	.11	.0100	.0000	0.2
8875	May 10	May 11	V. slight.	Slight.	0.05	1.70	0.55	.0000	.0090	.0076	.0014	.10	.0070	.0000	0.0
9082	July 11	July 12	V. slight.	Slight.	0.05	1.75	0.60	.0000	.0138	.0112	.0026	.14	.0000	.0000	0.8
9521	Oct. 12	Oct. 13	Slight.	Slight.	0.05	1.45	0.60	.0000	.0092	.0084	.0008	.10	.0030	.0000	0.2
Av.	....	....	....	....	0.05	2.00	0.75	.0000	.0106	.0084	.0022	.11	.0050	.0000	0.3

Odor, generally very faintly vegetable; in the last sample, distinctly vegetable when cold, very faint or none when hot.—The samples were collected from the pond, about five feet beneath the surface.

ASHBURNHAM.

Microscopical Examination of Water from Upper Naukeag Pond, Ashburnham.

[Number of organisms per cubic centimeter.]

	1892.			
	April.	May.	July.	October.
Day of examination,	5	11	12	13
Number of sample,	8696	8875	9082	9521
PLANTS.				
Diatomaceæ,	**40**	**32**	**44**	**6**
Asterionella,	0	4	25	0
Diatoma,	0	5	pr.	0
Fragilaria,	0	3	0	0
Synedra,	40	3	1	2
Tabellaria,	0	17	18	4
Cyanophyceæ. Nostoc,	**0**	**0**	**0**	**48**
Algæ,	**12**	**0**	**1**	**5**
Dictyosphærium,	8	0	0	0
Hyalotheca,	0	0	0	5
Nephrocytium,	4	0	0	0
Staurastrum,	pr.	0	1	0
ANIMALS.				
Infusoria,	**116**	**21**	**8**	**3**
Dinobryon cases,	116	21	8	pr.
Peridinium,	0	pr.	0	pr.
Vorticella,	0	0	0	3
Miscellaneous. Zoöglœa,	**0**	**2**	**2**	**7**
TOTAL,	168	55	55	69

WATER SUPPLY OF ATTLEBOROUGH.

Chemical Examination of Water from the New Well of the Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9449	Sept. 26	Sept. 27	V. slight.	V. slight.	0.0	3.50	.0000	.0000	.24	.0200	.0000	1.4	.0050
9450	Sept. 26	Sept. 27	Decided, clayey.	Slight, sandy.	0.2	4.50	.0000	.0016	.45	.0070	.0001	2.1	.0130

Odor, none.——The samples were collected during the construction of the new well, by boring holes through the planking on opposite sides of the well, about twenty-two feet below the surface of the ground. No. 9449 was collected from the hole on the east side, and No. 9450 from the one on the west side of the well. There was a decided difference in the temperature of the water from the two sides, the first being 53° and the second 61° at the time of collection.

Microscopical Examination.

No. 9449. Algæ, *Zoöspores*, pr.

No. 9450. Algæ, *Pediastrum*, 1. Infusoria, *Peridinium*, 1. Total, 2.

AVON.

WATER SUPPLY OF AVON.

Chemical Examination of Water from the Well of the Avon Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9258	Aug. 15	Aug. 17	None.	None.	0.0	3.70	.0000	.0000	.40	.0300	.0001	1.5	.0115

Odor, none.—— The sample was collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

WATER SUPPLY OF BELMONT.

(See *Watertown.*)

WATER SUPPLY OF BEVERLY.

(See *Salem.*)

WATER SUPPLY OF BOSTON.

The principal changes affecting the character of the Boston water supply during the past year are the completion of systems of sewage disposal in the city of Marlborough and the town of Westborough. Both of these systems provide for diverting the sewage to a point beyond the Sudbury River watershed, and for there purifying it by filtration through the ground.

A few connections were made with the Marlborough system in the latter part of 1891, and as soon as the weather would permit in the spring of 1892 additional connections were made as fast as practicable, so that since June a large and increasing proportion of the sewage of the city has been diverted from the Boston water supply.

At Westborough the system was first put in operation early in the autumn of 1892, but it then carried the sewage from only a limited portion of the town.

BOSTON.

The system of sewerage in the town of Framingham continues in operation, and is diverting from the water supply an increasing amount of sewage from South Framingham, the principal village of the town.

The works of the Jamaica Pond Aqueduct Company, which furnished a supply to a very small part of the city of Boston, were purchased by the city in 1892, and the works came into its possession at the end of the year. It is probable that this source will not be used in the future.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.	1892.													
8382	Jan. 4	Jan. 5	V. slight.	V. slight.	1.60	5.20	2.40	.0012	.0318	.0260	.0058	.26	.0100	.0001	1.3
8469	Feb. 1	Feb. 2	V. slight.	Slight.	1.10	4.75	1.90	.0002	.0198	.0184	.0014	.29	.0250	.0000	1.0
8560	Mar. 1	Mar. 2	None.	V. slight.	1.20	3.10	1.80	.0010	.0212	.0190	.0022	.27	.0070	.0000	0.9
8697	Apr. 4	Apr. 5	V. slight.	V. slight.	0.90	3.45	1.65	.0000	.0198	.0154	.0044	.21	.0020	.0000	0.6
8828	May 2	May 3	V. slight.	V. slight.	0.90	4.05	1.95	.0000	.0240	.0212	.0028	.26	.0030	.0000	1.1
8953	June 1	June 2	V. slight.	V. slight.	1.70	5.30	2.70	.0000	.0424	.0338	.0086	.17	.0070	.0000	1.0
9057	July 1	July 2	V. slight.	V. slight.	1.80	5.25	2.85	.0000	.0388	.0372	.0016	.18	.0050	.0000	1.2
9177	Aug. 1	Aug. 2	V. slight.	V. slight.	0.95	5.20	2.30	.0000	.0298	.0268	.0030	.30	.0000	.0000	0.8
9354	Sept. 6	Sept. 9	V. slight.	V. slight.	2.80	8.25	5.25	.0006	.0590	.0496	.0094	.16	.0200	.0004	1.7
9480	Oct. 3	Oct. 4	V. slight.	Slight.	1.35	6.30	2.90	.0000	.0292	.0262	.0030	.26	.0000	.0001	1.6
9615	Nov. 1	Nov. 3	V. slight.	V. slight.	0.95	4.90	2.05	.0000	.0222	.0178	.0044	.29	.0030	.0000	1.4
9742	Dec. 1	Dec. 2	V. slight.	V. slight.	2.00	6.05	3.15	.0008	.0316	.0278	.0038	.34	.0000	.0000	2.2
Av.	....	....	....	....	1.44	5.15	2.57	.0003	.0308	.0266	.0042	.25	.0068	.0001	1.2

Odor, distinctly vegetable, occasionally none; unchanged by heating. —— The samples were collected from the brook at its entrance to Reservoir No. 4.

Microscopical Examination.

Average number of organisms, 26 per cubic centimeter.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected One Foot beneath the Surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8383	Jan. 4	Jan. 5	V.slight.	V.slight.	0.50	3.25	1.25	.0000	.0166	.0152	.0014	.24	.0070	.0001	0.9
8470	Feb. 1	Feb. 2	Slight.	Slight.	0.75	4.25	1.50	.0002	.0210	.0196	.0014	.29	.0200	.0000	1.0
8561	Mar. 1	Mar. 2	V.slight.	V.slight.	0.75	3.80	1.40	.0012	.0210	.0186	.0024	.28	.0050	.0000	1.3
8698	Apr. 4	Apr. 5	Slight.	Slight.	0.70	3.40	1.60	.0000	.0176	.0152	.0024	.23	.0020	.0001	0.6
8829	May 2	May 3	Slight.	Slight.	0.55	3.40	1.25	.0000	.0184	.0158	.0026	.24	.0050	.0001	1.3
8954	June 1	June 2	V.slight.	V.slight.	0.65	3.30	1.90	.0002	.0222	.0170	.0052	.15	.0070	.0000	1.0
9058	July 1	July 2	V.slight.	Slight, white.	0.70	3.35	1.50	.0000	.0236	.0230	.0006	.20	.0000	.0000	1.1
9178	Aug. 1	Aug. 2	Slight, clayey.	V.slight.	0.55	3.75	1.55	.0000	.0228	.0192	.0036	.21	.0000	.0001	1.4
9355	Sept. 6	Sept. 9	Distinct.	Slight.	0.52	3.20	1.25	.0000	.0184	.0142	.0042	.22	.0150	.0004	0.8
9481	Oct. 3	Oct. 4	Distinct.	Slight.	0.50	3.80	1.45	.0000	.0142	.0058	.0084	.22	.0030	.0001	1.3
9616	Nov. 1	Nov. 3	Slight.	Cons.	0.55	3.35	1.45	.0000	.0206	.0174	.0032	.23	.0000	.0000	1.3
9743	Dec. 1	Dec. 2	Distinct, clayey.	Slight.	0.95	4.35	2.10	.0006	.0236	.0210	.0026	.26	.0090	.0000	1.8
Av.	....	....	....	....	0.64	3.60	1.52	.0002	.0200	.0168	.0032	.23	.0061	.0001	1.1

Odor, generally faintly vegetable or none.—— The samples were collected from the reservoir near the gate-house. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland, collected One Foot beneath the Surface.*

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Date of examination,	6	2	2	5	4	2	2	2	9	4	3	2
Number of sample,	8383	8470	8561	8698	8829	8954	9058	9178	9355	9481	9616	9743
PLANTS.												
Diatomaceæ,	**137**	**16**	**1**	**32**	**80**	**166**	**38**	**19**	**64**	**24**	**57**	**488**
Cyclotella,	102	10	0	0	36	72	36	16	58	7	15	406
Diatoma,	0	0	1	5	0	pr.	1	1	0	0	2	pr.
Meridion,	pr.	0	0	6	0	0	0	0	0	0	0	0
Navicula,	1	0	0	3	0	pr.	0	0	0	1	pr.	1
Synedra,	34	6	0	15	44	94	1	2	5	15	38	80
Tabellaria,	pr.	0	0	3	0	0	0	0	1	1	2	1

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland, collected One Foot beneath the Surface* — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	**10**	**13**	**0**	**0**	**67**	**4**	**10**	**0**	**5**	**170**	**35**	**19**
Chlorococcus,	0	0	0	0	0	4	0	0	0	8	7	15
Dictyosphærium,	0	0	0	0	14	0	0	0	0	0	0	0
Protococcus,	0	0	0	0	0	0	8	0	0	12	0	0
Raphidium,	2	12	0	0	52	0	0	0	5	148	28	2
Staurastrum,	3	0	0	0	pr.	0	2	0	0	1	0	1
Staurogenia,	5	1	0	0	1	0	0	0	0	1	pr.	1
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**3**	**pr.**	**pr.**
Infusoria,	**pr.**	**24**	**0**	**1**	**98**	**0**	**0**	**pr.**	**0**	**0**	**2**	**2**
Dinobryon,	0	17	0	0	pr.	0	0	0	0	0	2	0
Dinobryon cases,	0	7	0	0	98	0	0	0	0	0	0	0
Peridinium,	0	pr.	0	1	0	0	0	pr.	0	0	0	0
Trachelomonas,	pr.	0	0	0	0	0	0	pr.	0	0	pr.	1
Vorticella,	0	0	0	0	0	0	0	0	0	0	0	1
Vermes,	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**pr.**	**0**	**0**	**0**	**pr.**
Anurea,	0	0	0	0	0	0	pr.	pr.	0	0	0	pr.
Conochilus,	0	0	0	0	0	0	2	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	**14**	**1**	**0**	**28**	**42**	**4**	**24**	**0**	**114**	**168**	***20**	**226**
TOTAL,	161	54	1	61	287	174	74	19	183	365	114	735

* Zoöglœa and iron rust.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 4, Ashland, collected Twenty Feet beneath the Surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9332	Sept. 1	Sept. 2	V. slight.	V. slight.	0.50	3.40	1.35	.0006	.0180	.0162	.0018	.24	.0050	.0001	1.2

Odor, none. —— The samples were collected from the reservoir near the gate-house.

Microscopical Examination.

Total organisms, 196 per cubic centimeter.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected near the Bottom.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9333	Sept. 1	Sept. 2	V. slight.	V. slight.	0.48	3.45	1.45	.0002	.0142	.0108	.0034	.26	.0100	.0001	1.3

Odor, none. —— The sample was collected from the reservoir, near the gate-house, at a point where the reservoir is forty feet in depth when full.

Microscopical Examination.

Total organisms, 274 per cubic centimeter.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Sudbury River at the Upper End of Reservoir No. 2, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8384	Jan. 4	Jan. 5	Slight.	Slight.	1.20	5.35	2.30	.0020	.0254	.0222	.0032	.33	.0220	.0001	1.1
8471	Feb. 1	Feb. 2	Slight.	Slight.	0.85	4.70	1.75	.0000	.0156	.0144	.0012	.36	.0320	.0000	0.9
8562	Mar. 1	Mar. 2	Slight.	Slight.	0.90	4.75	1.65	.0006	.0172	.0156	.0016	.33	.0120	.0001	1.4
8699	Apr. 4	Apr. 5	Slight.	Slight.	0.80	3.20	1.40	.0000	.0174	.0162	.0012	.22	.0100	.0002	0.9
8830	May 2	May 3	Distinct.	Slight.	0.90	4.15	1.75	.0004	.0284	.0232	.0052	.32	.0050	.0001	1.4
8955	June 1	June 2	Slight.	Slight.	1.30	4.90	2.40	.0012	.0298	.0252	.0046	.17	.0070	.0000	1.2
9059	July 1	July 2	V. slight.	Slight.	0.90	4.25	2.15	.0014	.0326	.0286	.0040	.18	.0070	.0001	1.4
9180	Aug. 1	Aug. 2	Distinct, clayey.	Cons., brown.	0.80	4.95	2.35	.0000	.0306	.0242	.0064	.22	.0000	.0001	1.4
9336	Sept. 1	Sept. 2	V. slight.	Slight.	1.30	5.50	2.90	.0006	.0292	.0258	.0034	.28	.0050	.0001	1.7
9482	Oct. 3	Oct. 4	Distinct.	Slight.	0.65	4.50	1.70	.0008	.0200	.0184	.0016	.27	.0050	.0001	1.1
9599	Nov. 1	Nov. 2	Distinct.	Cons.	0.63	3.85	1.65	.0004	.0214	.0178	.0036	.30	.0070	.0002	1.1
9744	Dec. 1	Dec. 2	V. slight.	V. slight.	1.80	6.40	3.00	.0002	.0290	.0258	.0032	.44	.0070	.0000	1.9
Av.	....	....	....	....	1.00	4.71	2.08	.0006	.0247	.0214	.0033	.28	.0099	.0001	1.3

Odor, generally faintly vegetable, seldom mouldy, sometimes none. On heating, the odor is generally stronger. —— The samples were collected from the river near the old dam at the upper end of Reservoir No. 2, at a depth of about one foot beneath the surface.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Sudbury River at the Upper End of Reservoir No. 2, Ashland.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	2	2	5	4	2	2	2	3	4	2	2
Number of sample,	8384	8471	8562	8699	8830	8955	9059	9180	9336	9482	9599	9744
PLANTS.												
Diatomaceæ,	**6**	**1**	**4**	**2**	**60**	**154**	**4**	**57**	**34**	**25**	**54**	**7**
Cyclotella,	0	0	0	0	1	2	1	1	0	1	22	0
Diatoma,	0	1	2	0	6	11	0	1	0	0	0	0
Epithemia,	0	0	0	0	pr.	pr.	0	4	1	0	1	0
Fragilaria,	0	0	0	0	0	1	0	0	0	0	9	0
Grammatophora,	0	0	0	0	0	0	pr.	3	2	1	0	0
Melosira,	1	0	0	0	1	3	0	2	19	0	0	3
Navicula,	2	0	0	0	2	1	0	31	1	6	7	1
Synedra,	2	pr.	2	2	50	132	1	11	10	11	15	1
Tabellaria,	1	0	0	0	pr.	4	2	4	1	6	0	2
Cyanophyceæ. Anabæna,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**14**	**0**
Algæ,	**0**	**0**	**0**	**0**	**pr.**	**2**	**0**	**27**	**0**	**69**	**113**	**0**
Chlorococcus,	0	0	0	0	pr.	0	0	23	0	3	32	0
Hyalotheca,	0	0	0	0	0	0	0	0	0	6	0	0
Raphidium,	0	0	0	0	pr.	0	0	4	0	56	80	0
Scenedesmus,	0	0	0	0	0	2	0	pr.	0	4	1	0
Fungi,	**1**	**0**	**0**	**0**	**10**	**92**	**34**	**14**	**48**	**108**	**15**	**24**
Beggiatoa,	0	0	0	0	0	0	0	0	0	0	0	19
Crenothrix,	1	0	0	0	10	92	34	14	48	108	15	5
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**1**	**0**	**0**
Infusoria,	**0**	**1**	**3**	**7**	**pr.**	**6**	**0**	**6**	**4**	**4**	**0**	**0**
Dinobryon,	0	0	3	pr.	0	0	0	3	0	0	0	0
Dinobryon cases,	0	0	0	7	0	5	0	0	0	0	0	0
Peridinium,	0	1	pr.	0	0	0	0	1	3	2	0	0
Synura,	0	0	0	0	0	1	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	pr.	0	0	2	1	2	0	0
Vermes. Conochilus,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**62**	**16**	**3**	**0**	**128**	**490**	**36**	**344**	**240**	**120**	**188**	**2**
TOTAL,	69	18	10	9	198	744	74	450	326	327	384	33

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8385	Jan. 4	Jan. 5	Slight.	Slight.	1.10	5.50	2.50	.0012	.0284	.0216	.0068	.41	.0200	.0000	1.3
8474	Feb. 1	Feb. 2	V. slight.	V. slight.	0.90	4.30	1.55	.0004	.0176	.0162	.0014	.31	.0280	.0000	1.1
8563	Mar. 1	Mar. 2	Slight.	V. slight.	0.85	4.40	1.50	.0010	.0198	.0174	.0024	.32	.0140	.0000	1.3
8700	Apr. 4	Apr. 5	Slight.	Slight.	0.70	3.25	1.40	.0000	.0168	.0144	.0024	.22	.0090	.0000	0.9
8831	May 2	May 3	Slight.	Slight.	0.70	3.65	1.75	.0000	.0206	.0180	.0026	.28	.0050	.0001	1.1
8956	June 1	June 2	Slight.	Slight.	1.00	4.50	1.90	.0004	.0262	.0180	.0082	.16	.0090	.0000	1.0
9060	July 1	July 2	V. slight.	Slight.	1.00	4.25	2.50	.0000	.0320	.0280	.0040	.18	.0000	.0000	1.3
9179	Aug. 1	Aug. 2	Distinct, clayey.	Cons.	0.70	4.40	1.90	.0018	.0282	.0242	.0040	.28	.0000	.0001	1.4
9337	Sept. 1	Sept. 2	Distinct, green.	Cons., yellow.	0.60	4.05	1.90	.0000	.0236	.0196	.0040	.28	.0000	.0001	1.6
9483	Oct. 3	Oct. 4	Distinct, clayey.	Slight.	0.70	4.45	1.85	.0000	.0208	.0172	.0036	.25	.0000	.0001	1.4
9600	Nov. 1	Nov. 2	Slight.	Slight.	0.58	3.70	1.60	.0002	.0190	.0134	.0056	.30	.0090	.0002	1.3
9745	Dec. 1	Dec. 2	Slight, clayey.	Slight.	1.80	5.75	2.70	.0002	.0236	.0220	.0016	.44	.0050	.0000	1.7
Av.	....	....	....	....	0.89	4.35	1.92	.0004	.0231	.0192	.0039	.29	.0082	.0001	1.3

Odor, generally faintly vegetable or none; on heating the odor is much stronger, and occasionally mouldy or disagreeable. —— The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 2, Framingham.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	2	2	5	4	2	2	2	3	4	2	2
Number of sample,	8385	8474	8563	8700	8831	8956	9060	9179	9337	9483	9600	9745
PLANTS.												
Diatomaceæ,	8	6	5	6	123	80	65	5	10	129	223	11
Asterionella,	2	pr.	0	1	3	0	0	0	0	0	1	3
Cyclotella,	pr.	2	1	0	6	6	64	3	4	92	164	2
Diatoma,	0	pr.	0	0	4	12	0	0	0	0	pr.	0
Fragilaria,	0	0	1	0	0	2	0	1	0	0	1	0
Melosira,	0	2	1	0	0	0	0	0	0	0	2	3
Meridion,	pr.	pr.	pr.	3	pr.	pr.	0	0	0	0	0	0
Navicula,	1	1	1	pr.	pr.	pr.	0	pr.	2	1	2	2
Synedra,	5	1	1	2	100	52	0	1	4	36	46	0
Tabellaria,	0	0	0	0	10	8	1	0	0	0	7	1
Cyanophyceæ,	0	0	0	0	0	0	4	3	1,536	88	12	0
Anabæna,	0	0	0	0	0	0	0	0	1,536	88	12	0
Chroöcoccus,	0	0	0	0	0	0	4	3	0	0	0	0
Algæ,	0	1	0	0	12	8	51	91	10	49	40	0
Botrycoccus,	0	0	0	0	0	0	1	0	6	2	pr.	0
Chlorococcus,	0	0	0	0	0	2	7	90	0	0	22	0
Protococcus,	0	0	0	0	0	0	42	pr.	0	0	0	0
Raphidium,	0	0	0	0	11	5	0	1	0	47	18	0
Staurastrum,	0	1	0	0	1	1	1	0	4	0	0	0
Fungi. Crenothrix,	2	0	0	1	pr.	19	1	1	0	3	0	pr.
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	1	0	0	0	2	1
Actinophrys,	0	0	0	0	0	0	1	0	0	0	1	0
Difflugia,	0	0	0	0	0	0	0	0	0	0	1	1
Infusoria,	pr.	0	pr.	2	10	0	1	pr.	6	3	40	8
Dinobryon,	0	0	pr.	2	1	0	0	0	0	0	36	8
Dinobryon cases,	0	0	0	0	9	0	0	0	0	0	2	0
Epistylis,	0	0	0	0	0	0	0	0	0	3	0	0
Monas,	0	0	0	pr.	pr.	0	0	0	0	0	1	0
Peridinium,	pr.	0	pr.	0	0	0	pr.	0	6	0	0	pr.
Trachelomonas,	0	0	0	0	pr.	0	1	pr.	0	0	1	0
Vermes,	0	0	0	0	0	0	0	4	0	0	1	pr.
Conochilus,	0	0	0	0	0	0	0	4	0	0	0	0
Rotatorian ova,	0	0	0	0	0	0	0	0	0	0	1	pr.
Miscellaneous. Zoöglœa,	128	30	1	4	76	102	42	56	616	136	50	10
TOTAL,	138	37	6	13	221	209	165	160	2,178	408	368	30

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Walker's Brook,* Marlborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8425	Jan 16	Jan. 18	Slight.	Cons., earthy.	0.90	16.40	6.30	.0490	.0392	.0300	.0092	1.98	.7000	.0050	4.7
8475	Feb. 1	Feb. 2	Distinct.	Slight.	0.10	15.85	5.05	.0360	.0178	.0152	.0026	2.41	.5500	.0045	5.1
8568	Mar. 1	Mar. 2	Distinct.	Cons.	0.65	16.50	4.15	.0800	.0470	.0412	.0058	3.53	.4500	.0045	4.9
8706	Apr. 4	Apr. 5	Distinct	Heavy, earthy.	0.75	13.70	3.55	.0720	.0390	.0288	.0102	2.00	.3000	.0066	4.0
8841	May 3	May 4	Decided.	Cons.	0.65	13.45	3.20	.0640	.0320	.0256	.0064	2.01	.2600	.0045	5.3
8952	June 1	June 2	Distinct.	Cons.	0.30	15.40	3.35	.0090	.0236	.0154	.0082	2.28	.3000	.0020	5.0
9070	July 5	July 6	Distinct, clayey.	Slight.	0.55	17.85	4.20	.0110	.0272	.0240	.0032	2.90	.2500	.0070	6.0
9191	Aug. 2	Aug. 2	Decided, milky.	Slight, fibrous.	0.35	26.00	8.00	.0110	.0256	.0236	.0020	3.64	.2000	.0200	8.3
9327	Sept. 1	Sept. 1	Slight, milky.	Slight.	0.70	19.25	4.20	.0050	.0264	.0232	.0032	2.85	.1000	.0070	6.9
9479	Oct. 3	Oct. 4	V. slight.	V. slight	0.12	16.85	3.30	.0000	.0136	.0124	.0012	2.82	.1600	.0005	6.3
9598	Nov. 1	Nov. 1	V. slight.	V. slight.	0.08	14.85	2.95	.0000	.0122	.0086	.0036	2.30	.1000	.0015	5.7
9755	Dec. 5	Dec. 5	Distinct.	Slight.	0.70	16.00	3.90	.0316	.0250	.0224	.0026	2.29	.2000	.0010	6.0
Av.	....	......	....	....	0.49	16.84	4.35	.0307	.0274	.0225	.0048	2.58	.2975	.0037	5.7

Odor of the first six samples, offensive; of the last six, vegetable and occasionally disagreeable, becoming less strong toward the end of the year. —— The samples were collected from the brook at the first road bridge below Maple Street, about a mile south of the centre of the city of Marlborough.

* This brook drains the greater portion of the city of Marlborough, and is a tributary of Stony Brook, one of the tributaries of Sudbury River, above the point where the water supply of the city of Boston is taken. The city of Marlborough constructed a sewerage system in 1891, and the first houses were connected with the sewer in the latter part of that year. Since March, 1892, a large number of connections have been made, and the sewage, which was formerly discharged into vaults and cesspools within the watershed of Walker's Brook, has been carried outside the Sudbury River watershed. At the point where the samples were collected the brook drains an area of 2.05 square miles, or 2.7 per cent. of the drainage area of Sudbury River above the point where its waters are diverted by the city of Boston. This series of analyses is made in order to determine to what extent the pollution of the brook will be diminished by the introduction of the above-mentioned sewerage system.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Stony Brook, at Upper End of Reservoir No. 3, Southborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8386	Jan. 4	Jan. 5	Distinct, clayey.	Slight.	1.00	7.30	2.95	.0042	.0272	.0244	.0028	.50	.0600	.0002	1.9
8473	Feb. 1	Feb. 2	V.slight.	V.slight.	0.85	6.00	2.05	.0026	.0182	.0164	.0018	.53	.0580	.0002	1.7
8564	Mar. 1	Mar. 2	Slight.	V.slight.	0.85	5.55	1.65	.0040	.0240	.0194	.0046	.46	.0500	.0002	1.8
8701	Apr. 4	Apr. 5	Slight.	Slight.	0.85	4.45	1.90	.0016	.0228	.0202	.0026	.37	.0300	.0002	1.5
8832	May 2	May 3	Slight.	Slight.	1.00	5.30	2.25	.0004	.0308	.0278	.0030	.37	.0120	.0002	1.7
8957	June 1	June 2	Slight.	Slight.	1.40	6.20	2.50	.0020	.0378	.0280	.0098	.33	.0100	.0000	1.7
9061	July 1	July 2	None.	V.slight.	1.00	6.50	2.70	.0018	.0396	.0336	.0060	.44	.0070	.0002	1.6
9181	Aug. 1	Aug. 2	Slight.	Slight.	0.70	6.00	1.80	.0010	.0282	.0242	.0040	.46	.0000	.0002	2.2
9334	Sept. 1	Sept. 2	Slight, green.	Slight, rusty.	0.70	6.70	2.45	.0000	.0310	.0274	.0036	.63	.0050	.0002	2.2
9484	Oct. 3	Oct. 4	V.slight.	V.slight	0.75	6.55	2.50	.0000	.0280	.0262	.0018	.60	.0050	.0002	2.2
9601	Nov. 1	Nov. 2	V.slight.	V.slight.	0.55	5.80	1.95	.0000	.0256	.0226	.0030	.67	.0050	.0003	1.8
9746	Dec. 1	Dec. 2	V.slight.	V.slight.	1.90	7.95	3.45	.0004	.0362	.0328	.0034	.53	.0000	.0000	3.1
Av.	....	....	....	....	0.96	6.19	2.35	.0015	.0291	.0252	.0039	.49	.0202	.0002	1.9

Odor, generally distinctly vegetable, frequently mouldy and disagreeable or unpleasant. — The samples were collected from the brook, about fifty feet below the first road above Reservoir No. 3, at a depth of one foot beneath the surface.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Stony Brook, at Upper End of Reservoir No. 3, Southborough.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	2	2	5	4	2	2	2	3	4	2	2
Number of sample,	8386	8473	8564	8701	8832	8957	9061	9181	9334	9484	9601	9746
PLANTS.												
Diatomaceæ,	**4**	**4**	**7**	**235**	**117**	**53**	**58**	**pr.**	**361**	**23**	**2**	**3**
Diatoma,	pr.	0	pr.	27	5	pr.	0	0	0	0	0	pr.
Fragilaria,	0	0	0	26	4	5	0	0	0	0	1	0
Melosira,	1	0	0	17	50	2	53	0	248	21	0	3
Meridion,	1	2	5	4	pr.	0	0	pr.	0	0	0	0
Navicula,	pr.	pr.	pr.	5	6	pr.	0	0	1	2	0	0
Synedra,	2	2	2	156	52	46	5	0	112	0	1	pr.
Algæ,	**0**	**0**	**pr.**	**4**	**3**	**3**	**16**	**0**	**379**	**1**	**1**	**0**
Chlorococcus,	0	0	pr.	0	pr.	pr.	16	0	9	0	0	0
Closterium,	0	0	0	0	1	pr.	0	0	3	0	1	0
Protococcus,	0	0	0	0	0	0	0	0	292	1	0	0
Raphidium,	0	0	0	0	0	2	0	0	5	0	0	0
Scenedesmus,	0	0	0	pr.	2	1	0	0	10	0	0	0
Staurastrum,	0	0	0	3	0	0	0	0	3	0	0	0
Tetraspora,	0	0	0	0	0	0	0	0	52	0	0	0
Zoöspores,	0	0	0	1	0	0	0	0	5	0	0	0
Fungi. Crenothrix,	**1**	**pr.**	**pr.**	**3**	**56**	**38**	**36**	**84**	**10**	**36**	**17**	**0**
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**pr.**	**0**	**0**	**14**	**0**	**1**	**1**	**pr.**	**0**
Actinophrys,	0	0	0	pr.	0	0	14	0	1	0	0	0
Difflugia,	0	0	0	0	0	0	0	0	0	1	pr.	0
Infusoria,	**pr.**	**0**	**0**	**1**	**13**	**pr.**	**11**	**0**	**69**	**9**	**4**	**0**
Dinobryon,	0	0	0	0	0	0	0	0	44	0	4	0
Dinobryon cases,	0	0	0	0	11	0	6	0	0	8	0	0
Gonium,	0	0	0	1	0	0	0	0	1	0	0	0
Peridinium,	pr.	0	0	0	0	0	4	0	18	0	0	0
Phacus,	0	0	0	0	0	pr.	1	0	0	0	0	0
Trachelomonas,	0	0	0	pr.	2	0	pr.	0	6	1	0	0
Miscellaneous. Zoöglœa,	**78**	**pr.**	**9**	**5**	**102**	**9**	**34**	**0**	**312**	**40**	**0**	**0**
TOTAL,	83	4	16	248	291	103	169	84	1,132	110	24	3

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 3, Framingham.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8387	Jan. 4	Jan. 5	V. slight.	Cons.	0.80	6.75	2.05	.0052	.0236	.0212	.0024	.61	.0350	.0001	2.2
8472	Feb. 1	Feb. 2	Slight, clayey.	Slight.	0.85	5.85	2.15	.0048	.0202	.0184	.0018	.44	.0620	.0002	1.7
8565	Mar. 1	Mar. 2	V. slight.	V. slight.	0.85	5.80	1.60	.0048	.0200	.0178	.0022	.48	.0550	.0002	2.2
8702	Apr. 4	Apr. 5	Distinct.	Slight.	0.60	4.70	2.60	.0040	.0194	.0168	.0026	.33	.0280	.0001	1.3
8833	May 2	May 3	Slight.	Cons.	0.55	3.90	1.40	.0006	.0204	.0164	.0040	.32	.0350	.0002	1.4
8958	June 1	June 2	Distinct.	Cons.	0.80	4.85	1.80	.0036	.0264	.0222	.0042	.34	.0100	.0000	1.7
9062	July 1	July 2	Slight.	Cons., white.	0.90	4.80	2.40	.0014	.0372	.0304	.0068	.31	.0070	.0001	1.5
9182	Aug. 1	Aug. 2	Distinct.	Slight.	0.70	5.30	1.80	.0006	.0262	.0224	.0038	.38	.0000	.0003	1.9
9335	Sept. 1	Sept. 2	Slight, green.	Slight.	0.70	4.90	2.00	.0004	.0274	.0228	.0046	.39	.0030	.0002	2.0
9485	Oct. 3	Oct. 4	Distinct, green.	Cons., brown.	0.55	5.10	1.80	.0000	.0262	.0218	.0044	.26	.0030	.0001	1.8
9602	Nov. 1	Nov. 2	Slight.	Cons.	0.60	5.25	2.15	.0000	.0280	.0254	.0026	.44	.0030	.0003	1.5
9747	Dec. 1	Dec. 2	Distinct, clayey.	Slight.	0.75	4.85	1.95	.0034	.0298	.0274	.0024	.46	.0120	.0000	2.1
Av.	....	....	....	....	0.72	5.17	1.97	.0024	.0254	.0219	.0035	.40	.0211	.0001	1.8

Odor, vegetable, frequently mouldy and sometimes unpleasant or disagreeable. —— The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 3, Framingham.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	2	2	5	4	2	2	2	3	4	2	2
Number of sample,	8387	8472	8565	8702	8833	8958	9062	9182	9335	9485	9602	9747
PLANTS.												
Diatomaceæ,	**48**	**6**	**3**	**7**	**769**	**525**	**202**	**124**	**146**	**1,353**	**487**	**311**
Asterionella,	20	4	0	0	109	2	0	0	0	220	432	48
Cyclotella,	0	1	0	0	160	130	30	108	6	64	0	44
Diatoma,	1	0	0	0	28	2	0	0	0	0	0	0
Fragilaria,	1	0	0	0	8	0	0	0	0	0	0	0
Melosira,	1	0	3	0	0	2	0	0	6	0	6	1
Navicula,	5	0	0	0	0	0	pr.	0	2	0	1	0
Synedra,	15	1	0	6	444	7	pr.	pr.	12	13	2	14
Tabellaria,	5	0	0	1	20	382	172	16	120	1,056	46	204
Cyanophyceæ,	**2**	**0**	**0**	**0**	**3**	**2**	**11**	**1**	**131**	**57**	**24**	**1**
Anabæna,	0	0	0	0	0	0	1	0	5	44	7	0
Chroöcoccus,	2	0	0	0	2	0	0	0	0	12	0	0
Clathrocystis,	pr.	0	0	0	0	0	7	pr.	9	0	2	1
Cœlosphærium,	0	0	0	0	1	0	1	1	100	1	5	0
Microcystis,	0	0	0	0	0	2	2	pr.	17	0	0	0
Algæ,	**pr.**	**0**	**0**	**2**	**26**	**100**	**95**	**8**	**36**	**133**	**137**	**78**
Botryococcus,	0	0	0	0	0	0	3	0	1	0	3	1
Chlorococcus,	0	0	0	0	19	39	92	4	5	0	0	0
Closterium,	0	0	0	2	1	pr.	0	pr.	0	2	2	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	105	38	8
Nephrocytium,	0	0	0	0	0	0	0	0	6	0	0	0
Protococcus,	0	0	0	0	0	0	0	0	20	24	34	60
Raphidium,	0	0	0	0	2	56	pr.	3	0	0	52	1
Scenedesmus,	pr.	0	0	0	4	5	0	0	1	0	0	8
Staurastrum,	pr.	0	0	0	0	0	pr.	1	3	2	1	0
Staurogenia,	0	0	0	0	pr.	0	pr.	0	0	0	7	pr.
Fungi. Crenothrix,	**1**	**pr.**	**0**	**pr.**	**0**	**pr.**	**0**	**0**	**0**	**0**	**2**	**4**
ANIMALS.												
Rhizopoda,	**0**	**pr.**	**0**	**1**	**pr.**	**0**	**1**	**0**	**1**	**0**	**8**	**4**
Actinophrys,	0	0	0	1	0	0	1	0	1	0	6	3
Difflugia,	0	pr.	0	0	pr.	0	0	0	0	0	2	1
Infusoria,	**10**	**0**	**pr.**	**22**	**26**	**4**	**pr.**	**1**	**12**	**1**	**3**	**10**
Dinobryon,	6	0	0	3	2	0	0	0	0	0	0	9
Dinobryon cases,	4	0	0	19	24	4	0	0	0	0	0	0
Peridinium,	0	0	pr.	pr.	0	0	0	pr.	1	0	0	pr.
Trachelomonas,	pr.	0	0	0	0	0	pr.	1	11	1	3	1
Vermes,	**0**	**0**	**0**	**0**	**pr.**	**3**	**0**	**0**	**1**	**0**	**3**	**1**
Anurea,	0	0	0	0	0	pr.	0	0	1	0	0	0
Polyarthra,	0	0	0	0	pr.	0	0	0	0	0	2	1
Rotatorian ova,	0	0	0	0	0	pr.	0	0	0	0	1	0
Sacculus,	0	0	0	0	0	3	0	0	0	0	0	0
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**.01**	**.01**	**0**	**.02**	**0**	**.04**	**.04**	**0**
Miscellaneous. Zoöglœa,	**98**	**9**	**0**	**108**	**70**	**90**	**68**	**0**	**408**	**148**	**60**	**148**
TOTAL,	159	15	3	140	894	724	377	134	735	1,692	724	557

BOSTON.

COCHITUATE SUPPLY. — *Chemical Examination of Water from Lake Cochituate, in Wayland.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8388	Jan. 4	Jan. 5	V. slight.	Slight, green.	0.15	4.35	1.40	.0016	.0148	.0100	.0048	.47	.0220	.0001	1.8
8478	Feb. 1	Feb. 2	V. slight.	Slight.	0.25	4.90	1.65	.0014	.0158	.0134	.0024	.50	.0300	.0001	1.8
8570	Mar. 1	Mar. 3	Slight.	Slight.	0.20	4.40	1.05	.0050	.0182	.0162	.0020	.52	.0350	.0001	1.9
8703	Apr. 4	Apr. 5	Slight.	Slight.	0.15	4.80	1.30	.0000	.0164	.0116	.0048	.45	.0200	.0001	1.9
8834	May 2	May 3	Slight.	Slight.	0.15	4.70	1.30	.0004	.0186	.0158	.0028	.47	.0280	.0002	2.1
8959	June 1	June 2	Slight.	Slight.	0.10	4.75	1.40	.0048	.0166	.0118	.0048	.51	.0180	.0000	1.7
9063	July 1	July 2	V. slight.	Slight.	0.10	4.55	1.45	.0006	.0192	.0170	.0022	.44	.0090	.0003	1.8
9183	Aug. 1	Aug. 2	Distinct.	Slight, green.	0.12	4.70	1.00	.0004	.0204	.0150	.0054	.47	.0020	.0003	2.1
9338	Sept. 1	Sept. 2	Slight, green.	V. slight.	0.08	4.40	1.30	.0000	.0166	.0140	.0026	.50	.0000	.0001	2.2
9486	Oct. 3	Oct. 4	Slight.	Slight.	0.10	4.65	1.35	.0000	.0108	.0070	.0038	.44	.0050	.0002	2.1
9603	Nov. 1	Nov. 2	Slight.	V. slight.	0.10	4.50	1.35	.0000	.0158	.0120	.0038	.52	.0030	.0003	2.1
9748	Dec. 1	Dec. 2	Slight.	V. slight.	0.25	4.65	1.60	.0076	.0180	.0158	.0022	.50	.0100	.0000	2.6
Av.	....	....	....	....	0.15	4.61	1.35	.0018	.0168	.0133	.0035	.48	.0152	.0001	2.0

Odor, faintly vegetable or none; on heating, the odor is stronger, frequently grassy and sometimes unpleasant. —— The samples were collected in the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

COCHITUATE SUPPLY. — *Microscopical Examination of Water from Lake Cochituate, in Wayland.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	3	3	5	4	2	2	2	3	4	2	2
Number of sample,	8388	8478	8570	8703	8834	8959	9063	9183	9338	9486	9603	9748
PLANTS.												
Diatomaceæ,	**3,360**	**413**	**235**	**336**	**622**	**718**	**79**	**18**	**40**	**155**	**383**	**840**
Asterionella,	760	94	102	27	19	342	0	0	0	29	252	520
Cyclotella,	46	84	24	12	126	200	36	1	3	2	36	142
Diatoma,	0	0	pr.	0	2	7	0	0	0	0	0	0
Fragilaria,	6	0	8	0	0	15	4	0	0	87	4	6
Melosira,	2,536	224	96	238	224	7	1	4	33	31	86	142
Navicula,	4	0	pr.	0	0	1	0	1	0	0	0	1
Stephanodiscus,	0	0	0	0	pr.	0	0	0	0	0	1	15
Synedra,	4	9	1	56	234	48	7	11	3	2	0	2
Tabellaria,	4	2	4	3	17	98	31	1	1	4	4	12
Cyanophyceæ,	**27**	**38**	**10**	**6**	**pr.**	**0**	**33**	**93**	**84**	**9**	**34**	**44**
Anabæna,	22	35	10	0	pr.	0	6	42	64	1	21	44
Chroöcoccus,	4	3	0	6	0	0	11	6	0	0	8	0
Clathrocystis,	pr.	0	0	pr.	0	0	3	1	2	0	0	0
Cœlosphærium,	pr.	0	0	0	0	0	12	44	1	0	1	0
Mycrocystis,	1	0	0	0	0	0	1	pr.	17	8	4	pr.
Algæ,	**19**	**3**	**2**	**pr.**	**12**	**11**	**37**	**165**	**0**	**54**	**18**	**58**
Botrycoccus,	0	0	0	0	0	0	9	pr.	0	0	0	0
Chlorococcus,	16	2	0	0	3	2	17	16	0	0	2	2
Dictyosphærium,	0	0	0	0	8	0	0	0	0	0	0	0
Hyalotheca,	0	1	2	0	1	6	2	0	0	0	6	0
Protococcus,	0	0	0	0	0	0	9	1	0	48	10	56
Raphidium,	0	0	0	0	0	3	0	148	0	0	0	0
Sorastrum,	3	0	0	pr.	0	pr.	0	0	0	6	0	0
Fungi. Crenothrix,	**3**	**pr.**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**2**	**0**
ANIMALS.												
Rhizopoda,	**1**	**1**	**0**	**pr.**	**7**	**1**	**1**	**0**	**0**	**3**	**2**	**0**
Actinophrys,	1	1	0	pr.	7	pr.	1	0	0	3	2	0
Difflugia,	pr.	0	0	pr.	0	1	0	0	0	0	0	0
Infusoria,	**8**	**6**	**6**	**1**	**32**	**113**	**5**	**0**	**2**	**3**	**57**	**2**
Dinobryon,	0	pr.	0	1	18	1	5	0	0	0	7	0
Dinobryon cases,	4	4	0	0	11	112	pr.	0	0	0	50	pr.
Peridinium,	2	1	2	pr.	3	pr.	0	0	2	1	pr.	pr.
Synura,	0	1	3	0	pr.	0	0	0	0	0	0	0
Trachelomonas,	2	pr.	1	pr.	pr.	pr.	0	0	0	2	pr.	2
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**.01**	**.01**	**0**	**0**	**0**	**.04**	**.01**	**.01**
Miscellaneous. Zoöglœa,	**112**	**50**	**50**	**66**	**42**	**3**	**0**	**0**	**80**	**0**	**92**	**9**
TOTAL,	3,530	511	303	409	715	846	155	276	206	224	588	953

BOSTON.

COCHITUATE WORKS. — *Chemical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8389	Jan. 5	Jan. 5	V. slight.	Slight.	0.50	5.05	1.45	.0014	.0174	.0144	.0030	.50	.0220	.0001	1.7
8477	Feb. 2	Feb. 2	V. slight.	V. slight.	0.45	4.90	1.80	.0012	.0146	.0130	.0016	.50	.0450	.0001	1.8
8567	Mar. 2	Mar. 2	V. slight.	V. slight.	0.50	5.15	1.55	.0020	.0178	.0144	.0034	.51	.0350	.0002	1.7
8705	Apr. 5	Apr. 5	V. slight.	Slight.	0.40	4.55	1.60	.0000	.0182	.0118	.0064	.38	.0280	.0000	1.8
8837	May 3	May 3	V. slight.	Slight.	0.30	4.65	1.75	.0000	.0122	.0104	.0018	.38	.0350	.0001	1.7
8961	June 2	June 2	V. slight.	Slight.	0.25	4.30	1.50	.0040	.0154	.0134	.0020	.44	.0300	.0001	1.7
9064	July 2	July 2	V. slight.	V. slight.	0.32	4.70	1.90	.0000	.0166	.0132	.0034	.34	.0120	.0002	1.6
9185	Aug. 2	Aug. 2	V. slight.	V. slight.	0.35	4.75	1.75	.0000	.0184	.0168	.0016	.34	.0070	.0002	1.7
9339	Sept. 2	Sept. 2	Slight, green.	Slight, green.	0.20	4.30	1.70	.0000	.0174	.0126	.0048	.39	.0120	.0002	2.1
9487	Oct. 3	Oct. 4	V. slight.	Slight, brown.	0.30	4.70	1.75	.0000	.0170	.0148	.0022	.33	.0070	.0002	1.9
9604	Nov. 1	Nov. 2	Slight.	V. slight.	0.35	4.75	1.35	.0000	.0176	.0148	.0028	.40	.0090	.0002	1.7
9749	Dec. 1	Dec. 2	Slight, clayey.	V. slight.	0.50	4.55	1.90	.0004	.0188	.0162	.0026	.40	.0100	.0001	1.9
Av.	....	....	....	....	0.37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	1.9

Odor, faintly vegetable or none, rarely mouldy. On heating, the odor becomes stronger, and is frequently grassy, rarely unpleasant.

BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	3	3	5	4	2	2	2	3	4	2	2
Number of sample,	8389	8477	8567	8705	8837	8961	9064	9185	9339	9487	9604	9749
PLANTS.												
Diatomaceæ,	**346**	**237**	**172**	**159**	**270**	**154**	**161**	**70**	**39**	**23**	**103**	**146**
Asterionella,	116	87	48	82	44	48	0	0	0	0	50	90
Cyclotella,	13	26	36	4	74	86	48	5	5	5	9	14
Diatoma,	2	0	3	5	0	0	0	0	0	0	0	0
Fragilaria,	13	0	1	5	0	4	0	0	3	0	13	0
Melosira,	180	110	56	60	60	4	0	0	0	0	1	31
Synedra,	18	12	28	3	90	0	3	7	3	17	28	3
Tabellaria,	4	2	0	0	2	12	110	58	28	1	2	10
Cyanophyceæ,	**6**	**5**	**4**	**0**	**0**	**pr.**	**21**	**33**	**17**	**10**	**4**	**2**
Anabæna,	6	5	3	0	0	0	2	4	0	1	pr.	2
Chroöcoccus,	0	0	0	0	0	0	15	13	12	0	2	0
Clathrocystis,	0	0	0	0	0	0	1	1	4	1	0	0
Cœlosphærium,	0	pr.	1	0	0	0	3	14	1	0	2	0
Microcystis,	pr.	0	0	0	0	pr.	0	1	0	8	0	0
Algæ,	**pr.**	**0**	**2**	**0**	**0**	**0**	**32**	**19**	**9**	**0**	**6**	**3**
Chlorococcus,	pr.	0	2	0	0	0	32	10	1	0	0	1
Protococcus,	0	0	0	0	0	0	0	0	8	0	0	0
Raphidium,	0	0	0	0	0	0	0	9	0	0	6	2
Fungi. Crenothrix,	**2**	**9**	**1**	**0**	**pr.**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Rhizopoda. Actinophrys,	**pr.**	**pr.**	**2**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**5**	**5**	**3**	**pr.**	**4**	**5**	**pr.**	**pr.**	**3**	**2**	**0**	**4**
Dinobryon,	0	pr.	pr.	pr.	0	0	0	0	0	0	0	3
Dinobryon cases,	4	4	0	0	3	5	0	0	2	0	0	0
Monas,	0	pr.	0	pr.	0	0	0	0	1	0	0	0
Peridinium,	pr.	pr.	1	0	1	0	0	0	0	1	0	0
Synura,	1	pr.	1	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	1	1	0	0	0	pr.	pr.	0	1	0	1
Vermes. Rotifer,	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**60**	**6**	**6**	**4**	**88**	**114**	**20**	**1**	**388**	**56**	**0**	**18**
TOTAL,	419	262	191	163	362	273	234	123	456	91	113	175

BOSTON.

COCHITUATE WORKS. — *Chemical Examination of Water from a Faucet on Long Island, Boston Harbor.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8671	Mar. 25	Mar. 28	V. slight.	V. slight.	0.45	4.65	1.20	.0000	.0126	.0114	.0012	0.41	.0400	.0000	1.9

Microscopical Examination.

Diatomaceæ, *Asterionella*, 21; *Diatoma*, 1; *Melosira*, 19; *Navicula*, 1. Total, 42.

MYSTIC SUPPLY. — *Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000].

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8391	Jan. 5	Jan. 6	V. slight.	V. slight.	0.02	11.00	2.80	.0192	.0158	.0128	.0030	2.01	.0900	.0003	3.9
8482	Feb. 2	Feb. 3	Slight.	V. slight.	0.08	11.80	2.05	.0384	.0196	.0152	.0044	2.00	.1300	.0004	4.0
8569	Mar. 2	Mar. 3	Distinct, clayey.	V. slight.	0.10	10.00	2.65	.0440	.0260	.0218	.0042	1.59	.1250	.0008	3.9
8713	Apr. 6	Apr. 6	Distinct.	Slight.	0.10	10.00	1.35	.0400	.0226	.0166	.0060	1.63	.1400	.0005	3.4
8839	May 3	May 3	Distinct.	Cons., green.	0.08	10.50	2.40	.0270	.0276	.0156	.0120	1.82	.1250	.0005	3.6
8964	June 1	June 3	Distinct.	Cons.	0.05	10.30	1.50	.0090	.0270	.0170	.0100	1.88	.0600	.0006	3.6
9071	July 5	July 6	Slight.	Cons., rusty.	0.08	10.50	2.50	.0078	.0230	.0182	.0048	1.97	.0350	.0013	3.5
9193	Aug. 2	Aug. 3	Slight.	Slight.	0.08	11.05	1.60	.0010	.0176	.0134	.0042	2.30	.0150	.0003	3.9
9323	Sept. 1	Sept. 1	V. slight.	V. slight.	0.05	11.30	1.65	.0000	.0214	.0168	.0046	2.50	.0150	.0004	4.4
9494	Oct. 4	Oct. 5	Slight.	Slight.	0.05	15.30	3.05	.0000	.0142	.0092	.0050	3.71	.0150	.0010	5.3
9609	Nov. 2	Nov. 2	Distinct.	Cons., gray.	0.05	13.00	1.55	.0036	.0156	.0124	.0032	2.61	.0280	.0020	4.7
9754	Dec. 5	Dec. 5	Distinct.	Slight.	0.05	13.50	2.00	.0324	.0164	.0142	.0022	2.66	.0600	.0005	4.7
Av.	......	....	....	....	0.07	11.52	2.09	.0185	.0206	.0153	.0053	2.22	.0698	.0007	4.1

Odor, generally mouldy or vegetable, frequently disagreeable, rarely none. On heating, the odor is generally somewhat stronger. —— The samples were collected from the lake near the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

Mystic Supply. — *Microscopical Examination of Water from Mystic Lake.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	3	3	8	4	3	6	3	2	5	3	6
Number of sample,	8391	8482	8569	8713	8839	8964	9071	9193	9323	9494	9609	9754
PLANTS.												
Diatomaceæ,	**422**	**166**	**174**	**1,423**	**3,527**	**9,992**	**544**	**416**	**255**	**3,646**	**635**	**290**
Asterionella,	68	5	86	1,056	1,572	368	1	0	100	0	4	13
Cyclotella,	1	127	5	108	9	0	2	2	0	0	1	1
Diatoma,	248	0	76	200	1,060	40	6	0	0	0	0	52
Fragilaria,	1	0	0	0	47	1,064	528	142	39	48	14	14
Melosira,	3	8	2	21	18	0	1	0	0	6	8	6
Navicula,	1	0	pr.	pr.	9	8	pr.	0	0	0	4	0
Synedra,	100	20	5	38	812	8,512	6	272	116	3,592	604	204
Tabellaria,	0	6	0	0	0	0	pr.	0	0	0	0	0
Algæ,	**67**	**0**	**5**	**0**	**37**	**326**	**371**	**235**	**228**	**658**	**120**	**20**
Chlorococcus,	0	0	1	0	0	0	150	6	1	0	8	4
Closterium,	9	0	1	0	0	0	0	0	0	0	0	2
Cosmarium,	10	0	0	0	0	4	88	54	1	52	7	0
Nephrocytium,	0	0	0	0	0	0	8	0	0	0	0	0
Pediastrum,	0	0	0	0	0	0	7	1	2	2	1	0
Protococcus,	0	0	0	0	0	2	0	0	25	0	0	0
Raphidium,	2	0	0	0	8	172	26	30	0	8	0	2
Scenedesmus,	46	0	2	0	29	140	50	140	196	492	104	11
Staurastrum,	0	0	1	0	0	8	42	4	3	104	0	1
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Infusoria,	**pr.**	**pr.**	**1**	**0**	**1**	**20**	**17**	**172**	**152**	**216**	**1**	**2**
Dinobryon,	0	0	0	0	0	0	4	0	0	0	0	0
Dinobryon cases,	0	0	pr.	0	0	0	2	0	0	0	0	0
Monas,	pr.	0	1	0	0	0	0	0	0	0	0	0
Peridinium,	0	pr.	0	0	1	16	11	170	152	216	0	2
Trachelomonas,	pr.	pr.	0	0	0	4	0	2	0	0	1	0
Vermes,	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**1**	**0**	**0**
Anurea,	0	0	0	0	0	0	1	1	0	1	0	0
Polyarthra,	0	0	0	0	0	0	pr.	1	0	0	0	0
Rotatorian ova,	0	0	0	0	0	0	1	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	**7**	**2**	**290**	**128**	**13**	**0**	**120**	**120**	**72**	**0**	**44**	**180**
Total,	496	169	470	1,551	3,578	10,338	1,054	946	707	4,521	800	492

BOSTON.

MYSTIC SUPPLY. — *Chemical Examination of a Series of Samples from Different Points of the Mystic Supply.*

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8669	Mar. 24	Mar. 26	Decided, clayey.	Heavy, earthy.	0.10	9.10	2.90	.0336	.0416	.0216	.0200	1.02	.0750	.0020	3.2
8670	Mar. 24	Mar. 26	Decided, clayey.	Heavy, earthy.	0.25	9.70	2.20	.0130	.0486	.0220	.0266	1.79	.1100	.0020	3.1
8668	Mar. 24	Mar. 26	Decided, clayey.	Slight, earthy.	0.10	9.80	2.70	.0640	.0426	.0250	.0176	1.42	.0900	.0010	3.5
8663	Mar. 24	Mar. 25	Decided, clayey.	Cons., earthy.	0.30	9.80	2.80	.0480	.0486	.0342	.0144	1.42	.1250	.0025	3.6
8662	Mar. 24	Mar. 25	Distinct, clayey.	Slight, earthy.	0.10	11.20	2.10	.0400	.0292	.0226	.0066	1.82	.1250	.0025	3.6
8661	Mar. 24	Mar. 25	Distinct, clayey.	Cons., earthy.	0.10	11.00	2.50	.0480	.0260	.0186	.0074	1.82	.1100	.0005	3.8
8657	Mar. 22	Mar. 25	Slight, clayey.	None.	0.10	10.50	2.30	.0296	.0206	.0184	.0022	1.85	.1500	.0002	3.8
8664	Mar. 24	Mar. 25	Slight, clayey.	Slight.	0.10	10.90	2.10	.0160	.0200	.0160	.0040	1.77	.2000	.0002	3.8

Odor of 8664, vegetable; of all others, musty and generally unpleasant or disagreeable. —— The samples were collected as follows: No. 8669, from the Abbajona River at head of Wedge Pond; No. 8670, from mouth of Horn Pond Brook at Wedge Pond; No. 8668, from outlet of Wedge Pond; No. 8663, from mouth of Abbajona River at head of Mystic Lake; No. 8662, from Mystic Lake at head of conduit to pumping station; No. 8661, from pump well at Mystic pumping station, West Medford; No. 8657, from tap on Bunker Hill Street, Charlestown; No. 8664, from a tap in Chelsea.

BOSTON.

JAMAICA POND SUPPLY. — *Chemical Examination of Water from Jamaica Pond, at Various Depths, on Oct. 28, 1892.*

[Parts per 100,000.]

Number.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.				*6.90	*1.50									*.0050
9584	Oct. 29	Distinct.	Slight.	0.03	6.60	1.20	.0002	.0288	.0134	.0154	.79	.0050	.0003	2.9	.0020
					7.00	1.60									.0080
9585	Oct. 29	Distinct.	Cons., green.	0.03	6.20	1.60	.0012	.0308	.0150	.0158	–	.0050	.0004	3.0	.0020
					7.20	1.80									.0080
9586	Oct. 29	Distinct.	Cons., green.	0.03	6.70	1.80	.0012	.0312	.0172	.0140	–	.0070	.0005	3.0	.0050
					7.30	1.80									.0080
9587	Oct. 29	Distinct.	Cons., green.	0.03	6.70	1.90	.0048	.0296	.0166	.0130	–	.0070	.0005	2.9	.0040
					7.70	1.90									.1980
9588	Oct. 29	Distinct, milky.	Slight.	0.20	7.50	1.80	.2392	.0284	.0190	.0094	–	.0030	.0005	3.2	.1940
					18.90	3.30									.4100
9589	Oct. 29	Decided.	Much, earthy.	0.15	8.00	1.40	.4420	.0956	.0250	.0706	.78	.0000	.0007	3.4	.3200

The samples were collected in the order of their numbers, at the following depths, in feet, beneath the surface: 0.5, 10, 20, 30, 40 and 47, the deepest sample being taken a short distance above the bottom of the pond. The first two samples were odorless; the next two had a vegetable odor, and the odor of the last two was offensive. The color of No. 9588 increased to 0.70 and of No. 9589 to 1.30 after standing one day.

* The upper line of figures in these columns represents determinations made upon the water before filtration through filter-paper.

JAMAICA POND SUPPLY. — *Microscopical Examination of Water from Jamaica Pond, at Various Depths.*

[Number of organisms per cubic centimeter.]

	1892. Oct.	Oct.	Oct.	Oct.	Oct.	Oct.
Day of examination,	29	29	29	29	29	29
Number of sample,	9584	9585	9586	9587	9588	9589
Depth below surface (feet),	0.5	10	20	30	40	47
PLANTS.						
Diatomaceæ,	**10**	**2**	**0**	**0**	**12**	**2,278**
Asterionella,	0	0	0	0	0	2
Cyclotella,	0	2	0	0	0	12
Diatoma,	0	0	0	0	4	0
Melosira,	0	0	0	0	0	30
Navicula,	2	0	0	0	0	2
Synedra,	8	0	0	0	8	2,232

Microscopical Examination — Concluded.

[Number of organisms per cubic centimeter.]

	1892.					
	Oct.	Oct.	Oct.	Oct.	Oct.	Oct.
PLANTS — Con.						
Cyanophyceæ,	2,760	1,416	1,176	1,912	1,113	1,058
Anabæna,	2,760	1,416	1,176	1,912	1,112	1,048
Aphanocapsa,	0	0	0	0	0	2
Clathrocystis,	0	0	0	0	0	8
Oscillaria,	0	0	0	0	1	0
Algæ,	4	6	1	0	0	4
Closterium,	2	0	0	0	0	0
Cosmarium,	0	4	0	0	0	0
Scenedesmus,	0	0	0	0	0	2
Sorastrum,	2	0	1	0	0	0
Staurastrum,	0	2	0	0	0	0
Tetraspora,	0	0	0	0	0	2
Fungi. Crenothrix,	12	6	1	4	2	0
ANIMALS.						
Rhizopoda. Difflugia,	0	0	0	0	0	4
Infusoria,	0	0	0	2	0	2
Monas,	0	0	0	2	0	0
Peridinium,	0	0	0	0	0	2
Crustacea. Cyclops,	0	.04	.08	0	0	0
Miscellaneous. Zoöglœa,	22	22	9	30	608	3,640
TOTAL,	2,808	1,452	1,187	1,948	1,735	6,986

Chemical Examination of Snow collected at the Massachusetts Institute of Technology, Boston.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8574	Mar. 3	Mar. 4	Slight.	Slight, black.	0.0	–	–	.0252	.0040	.0012	.0028	.14	.0000	.0000	0.3
8575	Mar. 3	Mar. 4	Slight.	Cons., black.	0.0	–	–	.0234	.0088	.0042	.0046	.16	.0000	.0002	0.8
8641	Mar. 18	Mar. 19	V. slight.	Cons., black.	0.0	–	–	.0072	.0048	–	–	.10	.0000	.0003	0.0
Av.	....	....	....	....	0.0	–	–	.0186	.0059	–	–	.13	.0000	.0002	0.4

Odor of all samples, distinctly sooty. —— No. 8574 was collected from the roof of the Walker Building; No. 8575 was collected on the Newbury Street side of the Walker Building; and No. 8641 on the Boylston Street side.

BOSTON.

Table showing the Average Monthly Heights in Feet above Tide-marsh Level of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the Year 1892.

MONTHS.	Reservoir No. 2. Flash Boards, 167.12.	Reservoir No. 3. Stone Crest, 175.24.	Reservoir No. 4. Flash Boards, 215.21.	Farm Pond. High Water, 149.25.	Lake Cochituate. High Water, 134.36.	Mystic Lake. High Water, 7.00.
January,	166.02	173.17	211.91	148.49	129.03	5.26
February,	166.02	175.34	214.44	148.60	130.04	5.17
March,	166.06	174.89	214.58	148.94	131.31	5.08
April,	166.26	175.50	214.48	149.09	133.39	6.41
May,	167.56	175.42	214.94	149.19	134.27	6.69
June,	167.58	175.58	215.22	149.26	134.15	6.71
July,	165.74	173.61	215.12	149.27	133.05	6.22
August,	162.20	170.41	213.24	148.95	131.48	3.78
September,	164.97	169.74	206.41	149.04	130.17	2.77
October,	163.74	170.05	193.34	148.73	128.79	1.47
November,	162.90	171.18	187.70	148.72	127.81	2.15
December,	165.14	173.82	192.61	148.71	127.93	5.52

WATER SUPPLY OF BRADFORD. — BRADFORD WATER COMPANY.

Two new wells were added to the system of supply in 1892, making thirteen in all connected with the works. Twelve of these wells are located on Porter's Island, and the other one on the south-westerly bank of the river opposite the island. Eleven of the wells on the island are in a line about 1,300 feet long, and for convenience of reference they have been numbered from 1 to 12, beginning at the south-easterly end of the line. The remaining well is near the middle of the island.

Analyses of water taken from these wells in April, 1891, did not contain any free ammonia, while samples collected monthly from July to December, 1892, showed an unusually large and increasing amount. These more recent samples have also shown an increasing amount of iron, and both this and the free ammonia indicate that the water has been in contact with decomposing organic matter in the ground where free oxygen was absent. On account of this change in the character of the water, samples were taken on Nov. 4, 1892, to determine the character of the water in each of the wells, and the results are given in tables which follow.

BRADFORD.

The wells are from sixteen and one-half to twenty-four feet in depth, have wooden curbs and are covered with loose planks. A portion if not all of the wells are sunk in a material consisting of silt and sand deposited by the river.

Chemical Examination of Water from the Wells of the Bradford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9090	July 12	July 13	Distinct, milky.	Slight.	*0.00	9.90	.0174	.0016	.28	.0600	.0000	2.1	-
9200	Aug. 5	Aug. 6	Slight.	Cons., rusty.	0.00	5.75	.0210	.0014	.29	.0700	.0000	2.0	.0720
9385	Sept. 16	Sept. 16	Distinct, milky.	Slight, rusty.	0.00	5.65	.0280	.0026	.27	.0800	.0003	2.3	.0950
9685	Nov. 16	Nov. 17	Distinct, milky.	Slight.	†0.10	5.85	.0260	.0044	.25	.0700	.0010	3.1	.0900
9803	Dec. 15	Dec. 16	Distinct, milky.	Slight, rusty.	0.05	5.80	.0386	.0046	.32	.1000	.0001	2.5	.1520
Av.	....	....	....	....	0.03	6.59	.0262	.0029	.28	.0760	.0003	2.4	.1022

Odor of 9385, distinctly disagreeable; of all others, none. On heating, the odor of 9385 disappeared, but a mouldy odor was detected in No. 9200 and a fainter odor in No. 9685. —— The samples were collected from a faucet at the pumping station, except No. 9685, which was collected from a faucet near the centre of the distributing system.

* After standing twenty-four hours, the color became 0.25.
† Before filtration through filter-paper, the color was 0.3.

Microscopical Examination of Water from the Wells of the Bradford Water Company.

[Number of organisms per cubic centimeter.]

	1892. July.	1892. Aug.	1892. Sept.	1892. Nov.	1892. Dec.
Day of examination, ...	12	6	17	17	17
Number of sample, ...	9090	9200	9385	9685	9803
Miscellaneous. Zoöglœa, ...	238	*736	*480	104	*8,000

* Zoöglœa and iron rust.

BRADFORD.

Chemical Examination of Water from Each of the Wells of the Bradford Water Company.

[Parts per 100,000.]

No. of Well.	No. of Sample.	Appearance.			Residue on Evaporation.		Ammonia.		Chorine.	Nitrogen as		Hardness.	Iron.	
		Turbidity.	Sediment.	Color.	Unfiltered.	Filtered.	Free.	Albuminoid.		Nitrates.	Nitrites.		Unfiltered.	Filtered.
1	9621	None.	Slight.	0.00 *0.03	4.90	4.40	.0214	.0036	.22	.0120	.0002	2.5	.0640	.0500
2	9622	Decided, milky.	Slight.	0.01 0.01	5.50	4.30	.0256	.0028	.22	.0090	.0002	2.3	.1800	.0400
3	9623	None.	V. slight.	0.01 0.10	6.50	6.50	.0098	.0016	.24	.0070	.0002	2.7	.0580	.0540
4	9624	Distinct, milky.	Slight.	0.02 0.02	5.30	5.00	.0416	.0038	.30	.0000	.0001	3.5	.1000	.0140
5	9625	Slight, milky.	Slight.	0.02 0.00	4.50	4.50	.0102	.0016	.16	.0150	.0002	2.2	.0480	.0200
6	9626	Slight, milky.	Slight.	0.00 0.00	5.00	3.70	.0144	.0020	.21	.0260	.0004	2.1	.0860	.0020
7	9627	Decided.	Cons.	0.20 0.12	7.20	6.80	.0960	.0054	.21	.0000	.0000	2.7	.3450	.0780
8	9628	Decided, milky.	Cons.	0.00 0.00	5.50	4.00	.0520	.0030	.22	.0350	.0003	2.1	.2300	.0020
9	9629	Decided, milky.	Slight.	0.15 0.03	4.60	4.50	.0274	.0040	.26	.0900	.0005	2.1	.1000	.0650
10	9630	Decided, milky.	Cons.	1.00 0.70	5.90	5.80	.0560	.0080	.21	.0350	.0002	2.1	.3850	.3100
11	9631	Slight, milky.	Slight.	0.00 0.00	7.70	7.60	.0196	.0028	.38	.2500	.0005	2.9	.0600	.0040
12	9632	None.	V. slight.	0.00 0.00	6.80	6.30	.0000	.0000	.42	.1800	.0001	2.6	.0000	.0000
13	9633	Distinct, milky.	Slight.	0.01 0.00	13.10	10.00	.0000	.0036	.69	.0000	.0000	7.1	.1550	.0020

Odor of Nos. 9627 and 9630, distinct; of No. 9624, faint; of all others, none. There was very little change on heating. —— The samples were collected directly from the wells on November 4, and were examined on the following day.

* The lower line of figures in this column represents determinations made upon the water after it had been standing three days.

BRADFORD.

Microscopical Examination of Water from Each of the Wells of the Bradford Water Company.

[Number of organisms per cubic centimeter.]

	Number of Well.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of sample, . . .	9621	9622	9623	9624	9625	9626	9627	9628	9629	9630	9631	9632	9633
PLANTS.													
Diatomaceæ, . . .	24	0	0	0	0	0	20	0	0	0	0	0	0
Asterionella, ...	2	0	0	0	0	0	0	0	0	0	0	0	0
Grammatophora, . . .	2	0	0	0	0	0	0	0	0	0	0	0	0
Melosira, ...	20	0	0	0	0	0	20	0	0	0	0	0	0
Miscellaneous. Zoöglœa, .	*208	*328	424	*264	*184	*288	*312	*688	376	160	80	120	*1,360
Total, ...	232	328	424	264	184	288	332	688	376	160	80	120	1,360

The samples were examined Nov. 8, 1892.

* Zoöglœa and iron rust.

Water Supply of Braintree.

Chemical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8742	Apr. 14	Apr. 16	None.	None.	0.02	4.50	.0000	.0016	.76	.0420	.0000	1.7	–
9032	June 22	June 23	None.	None.	0.08	4.95	.0000	.0060	.76	.0200	.0000	1.6	–
9229	Aug. 10	Aug. 11	Slight, milky.	V. slight.	0.10	4.55	.0000	.0032	.74	.0100	.0003	1.6	.0290
9312	Aug. 27	Aug. 27	V. slight.	None.	0.00	4.85	.0000	.0008	.76	.0090	.0000	2.3	.1000
9321	Aug. 31	Sept. 1	V. slight, milky.	None.	*0.00	4.00	.0014	.0050	.76	.0100	.0003	1.9	.1000
9373	Sept. 14	Sept. 15	None.	None.	†0.00	4.95	.0000	.0010	.74	.0180	.0000	1.4	.0050
9529	Oct. 12	Oct. 14	None.	None.	0.00	4.60	.0000	.0022	.73	.0150	.0000	1.7	.0000
9654	Nov. 9	Nov. 10	None.	V. slight.	0.00	4.55	.0000	.0024	.73	.0090	.0000	1.9	.0010
9774	Dec. 8	Dec. 9	None.	None.	0.00	5.25	.0000	.0046	.80	.0400	.0000	2.1	.0050
Av.	....	....	....	....	0.02	4.69	.0002	.0030	.75	.0192	.0001	1.8	.0343

Odor of 9229, very faintly vegetable; of all others, none. On heating, the only change was the development of a distinct odor in No. 9321.—— The samples were collected from a faucet at the pumping station.

* After standing two days the color was 0.08. † After standing eight days the color was 0.04.

BRAINTREE.

Microscopical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Number of organisms per cubic centimeter.]

	1892.								
	Apr.	June.	Aug.	Aug.	Sept.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	23	12	27	2	15	14	12	9
Number of sample,	8742	9032	9229	9312	9321	9373	9529	9654	9774
PLANTS.									
Fungi. Crenothrix,	pr.	0	4,476	0	200	0	0	3	0
ANIMALS.									
Vermes. Anurea,	0	0	0	0	1	0	0	0	0
Miscellaneous. Zoöglœa,	0	0	40	0	64	0	0	17	0
TOTAL,	pr.	0	4,516	0	265	0	0	20	0

Water Supply of Brockton.

At the time of constructing the pumping station and tank, in 1891, provision was made for aerating the water by forcing air into it through a system of small pipes laid near the bottom of the tank. Three two-inch galvanized-iron pipes radiate from a point at the side of the tank, and each is provided at regular intervals with branches of brass tubing, one-fourth to three-eighths of an inch in diameter, perforated with holes one-seventh of an inch in diameter every three feet. Air is forced through this system of pipes from a compressor having sufficient capacity to furnish 172,000 cubic feet of air every twenty-four hours. The pipes are so arranged that each of the three main pipes supplies about one-third of the horizontal area of the tank.

On Sept. 15, 1892, two samples of water, one collected before and one after being aerated, were examined chemically and microscopically, and the results, which are given in detail on pages 113 and 114, do not show any change in the character of the water, which can be attributed to the aeration. The water had at this time, however, no odor before aeration, so that these examinations did not test the efficiency of this process in the matter of the removal of odors.

BROCKTON.

Chemical Examination of Water from Salisbury Brook at the Point where it enters the Storage Reservoir.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8439	Jan. 20	Jan. 21	V.slight.	V.slight	0.68	3.25	1.50	.0004	.0106	.0092	.0014	.23	.0020	.0000	0.3
8500	Feb. 10	Feb. 11	None.	Slight.	0.80	4.50	1.55	.0000	.0176	.0140	.0036	.40	.0020	.0000	0.8
8600	Mar. 9	Mar. 10	V.slight.	Cons.	0.90	3.70	1.55	.0002	.0136	.0122	.0014	.42	.0040	.0001	0.5
8726	Apr. 12	Apr. 13	None.	V.slight.	1.00	3.45	1.55	.0008	.0254	.0230	.0024	.34	.0020	.0000	0.5
8876	May 10	May 11	V.slight.	V.slight.	1.50	4.70	2.45	.0000	.0286	.0258	.0028	.32	.0100	.0001	0.8
8980	June 8	June 9	None.	V.slight.	2.10	6.75	2.55	.0006	.0488	.0402	.0086	.35	.0100	.0001	1.1
9095	July 12	July 13	V.slight.	V.slight.	1.30	5.95	3.15	.0006	.0322	.0274	.0048	.35	.0000	.0000	1.6
9515	Oct. 11	Oct. 12	V.slight.	V.slight.	0.85	7.95	2.70	.0018	.0282	.0250	.0032	.77	.0000	.0000	2.2
9658	Nov. 9	Nov. 10	V.slight.	V.slight.	0.90	8.00	3.05	.0008	.0310	.0274	.0036	.80	.0000	.0000	2.2
9762	Dec. 6	Dec. 7	None.	V.slight.	1.20	6.85	3.00	.0004	.0240	.0168	.0072	.60	.0000	.0000	2.1
Av.	....	....	....	....	1.12	5.51	2.30	.0006	.0260	.0221	.0039	.46	.0030	.0000	1.1

Odor, decidedly vegetable, unchanged by heating. —— The samples were collected from the brook just above the reservoir.

Microscopical Examination.

The total number of organisms present in these samples varied from 0 to 43, and averaged 20 per cubic centimeter.

Chemical Examination of Water from Salisbury Brook Storage Reservoir, collected One Foot beneath the Surface.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8413	Jan. 11	Jan. 12	Slight.	Slight.	0.80	4.25	1.75	.0010	.0176	.0152	.0024	.34	.0070	.0000	0.5
8501	Feb. 10	Feb. 11	Slight.	V.slight.	0.70	3.95	0.85	.0004	.0182	.0144	.0038	.36	.0070	.0000	0.6
8601	Mar. 9	Mar. 10	Slight.	Slight.	0.80	3.60	1.00	.0016	.0136	.0116	.0020	.37	.0050	.0001	0.6
8727	Apr. 12	Apr. 13	Slight.	Cons.	0.40	2.95	0.90	.0004	.0174	.0154	.0020	.36	.0030	.0000	1.0
8877	May 10	May 11	Distinct.	Cons.	0.50	2.85	1.15	.0002	.0168	.0122	.0046	.35	.0030	.0000	0.2
8981	June 8	June 9	Distinct.	Slight.	0.60	3.35	2.05	.0002	.0214	.0184	.0030	.36	.0000	.0000	0.3
9096	July 12	July 13	Slight.	Cons., green.	0.60	3.10	1.40	.0000	.0230	.0178	.0052	.34	.0030	.0000	0.8
9216	Aug. 9	Aug. 10	Slight.	Cons., green.	0.45	3.45	1.40	.0004	.0238	.0198	.0040	.38	.0050	.0000	0.9
9369	Sept. 13	Sept. 14	Distinct.	Cons., green.	0.45	3.25	1.70	.0000	.0258	.0210	.0048	.31	.0030	.0003	0.5
9516	Oct. 11	Oct. 12	Distinct.	Cons., yellow.	0.50	2.90	1.10	.0000	.0256	.0172	.0084	.37	.0000	.0000	0.8
9659	Nov. 9	Nov. 10	Distinct.	Cons., green.	0.30	3.10	1.30	.0010	.0288	.0198	.0090	.36	.0000	.0000	1.4
9763	Dec. 6	Dec. 7	Distinct, green.	Slight.	0.55	4.20	1.80	.0000	.0240	.0186	.0054	.44	.0000	.0000	1.3
Av.	....	....	....	....	0.55	3.41	1.37	.0004	.0213	.0168	.0045	.36	.0030	.0000	0.7

Odor, generally distinctly vegetable, sometimes disagreeable, rarely none. In November the odor was offensive. —— The samples were collected from the reservoir, at a depth of about one foot beneath the surface. The reservoir was full, or nearly so, until July, and lowered gradually until November, when it was forty-five inches below high water. At the time the last sample was collected it had risen to within twelve inches of high water.

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir, collected One Foot beneath the Surface.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	11	11	13	11	10	13	10	15	12	11	9
Number of sample,	8413	8501	8601	8727	8877	8981	9096	9216	9369	9516	9659	9763
PLANTS.												
Diatomaceæ,	**64**	**18**	**127**	**136**	**433**	**1,514**	**425**	**394**	**1,035**	**1,809**	**512**	**227**
Asterionella,	29	12	12	36	184	24	64	41	46	68	13	4
Cyclotella,	0	0	9	0	3	2	14	0	0	0	0	0
Diatoma,	0	0	0	5	0	144	304	116	8	35	pr.	13
Melosira,	13	0	2	3	108	180	10	4	4	160	12	0
Navicula,	pr.	0	0	pr.	3	0	0	0	0	2	1	pr.
Synedra,	21	6	96	10	3	276	5	9	1	216	370	200
Tabellaria,	1	0	8	82	132	888	28	224	976	1,328	116	10
Cyanophyceæ. Chroöcoccus,	**0**	**0**	**0**	**0**	**0**	**0**	**28**	**0**	**0**	**8**	**4**	**0**
Algæ,	**68**	**0**	**pr.**	**3**	**1**	**12**	**45**	**22**	**24**	**45**	**38**	**1**
Chlorococcus,	4	0	0	2	0	8	18	18	0	13	23	0
Closterium,	4	0	0	0	0	0	0	0	0	5	0	pr.
Dictyosphærium,	21	0	0	0	0	0	0	0	0	0	0	0
Pediastrum,	0	0	0	0	0	2	2	0	1	3	1	0
Protococcus,	0	0	0	0	0	0	0	0	10	8	0	0
Raphidium,	pr.	0	0	0	0	0	15	0	8	4	0	0
Scenedesmus,	30	0	pr.	pr.	1	2	2	0	4	4	12	1
Staurastrum,	0	0	0	0	0	0	3	4	1	5	1	pr
Tetraspora,	0	0	0	0	0	0	5	0	0	3	pr.	0
Zoöspores,	9	0	pr.	1	0	0	0	0	0	0	1	0
Fungi. Crenothrix,	**5**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**4**	**pr.**	**2**	**0**	**0**
Actinophrys,	0	0	0	0	0	1	2	3	pr.	0	0	0
Difflugia,	0	0	0	0	0	0	0	1	0	2	0	0
Infusoria,	**11**	**0**	**20**	**69**	**3**	**4**	**31**	**41**	**5**	**85**	**2**	**18**
Cryptomonas,	2	0	0	0	0	0	0	0	0	0	0	1
Dinobryon,	8	0	5	66	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	8	0	0	0	0	0	0	0	0	0
Heteronema,	0	0	4	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	0	0	16
Peridinium,	1	pr.	3	3	2	0	29	40	3	84	0	1
Trachelomonas,	pr.	0	pr.	0	1	4	2	1	2	1	pr.	0
Vorticella,	0	0	0	0	0	0	0	0	0	0	2	0
Vermes,	**0**	**pr.**	**0**	**0**	**4**	**1**	**7**	**0**	**2**	**3**	**pr.**	**1**
Anurea,	0	0	0	0	1	1	0	0	0	2	pr.	1
Asplanchna,	0	pr.	0	0	1	0	0	0	0	0	0	0
Polyarthra,	0	0	0	0	2	0	7	0	2	1	0	0
Miscellaneous. Zoöglœa,	**86**	**0**	**11**	**5**	**256**	**196**	**7**	**172**	**0**	**184**	**104**	**1**
TOTAL,	234	18	158	213	698	1,729	545	633	1,066	2,136	660	248

BROCKTON.

Chemical Examination of Water from the Brockton Water Works before and after Aeration in the Open Tank.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9379	Sept. 15	Sept. 16	Slight.	Slight, green.	0.50	3.40	1.40	.0000	.0246	.0236	.0010	.38	.0100	.0001	1.0
9380	Sept. 15	Sept. 16	Slight.	Cons.	0.50	3.45	1.75	.0000	.0236	.0208	.0028	.38	.0100	.0001	0.8

Odor, cold, none; when heated, the first was faintly vegetable and unpleasant and the second faintly vegetable. —— The first sample was collected from the pipe which conveys water to the pumps located near the tank, and represents the water before being aerated. The second sample was collected from a faucet below the tank, and represents the water after aeration. The amount of iron in these samples was respectively, .0400 and .0425 parts per 100,000.

Microscopical Examination of Water from the Brockton Water Works before and after Aeration in the Open Tank.

[Number of organisms per cubic centimeter.]

	1892. September.	1892. September.
Day of examination,	16	16
Number of sample,	9379	9380
PLANTS.		
Diatomaceæ,	1,617	844
Asterionella,	3	5
Cyclotella,	1	0
Diatoma,	15	22
Melosira,	0	9
Navicula,	0	1
Synedra,	58	64
Tabellaria,	1,540	744
Cyanophyceæ,	1	1
Clathrocystis,	pr.	1
Cœlosphærium,	1	0
Algæ,	52	32
Arthrodesmus,	3	3
Chlorococcus,	4	10
Pediastrum,	3	1
Protococcus,	8	6
Raphidium,	7	3
Scenedesmus,	20	6
Staurastrum,	4	
Staurogenia,	3	

BROCKTON.

Microscopical Examination of Water from the Brockton Water Works before and after Aeration in the Open Tank — Concluded.

[Number of organisms per cubic centimeter]

	1892. September.	1892. September.
ANIMALS.		
Rhizopoda. Difflugia,	1	1
Infusoria. Trachelomonas,	5	3
Miscellaneous. Zoöglœa,	0	242
Total,	1,676	1,123

Water Supply of Cambridge.

Chemical Examination of Water from Fresh Pond, Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8390	Jan. 5	Jan. 5	Slight.	Cons., green.	0.20	7.60	1.75	.0088	.0210	.0174	.0036	.73	.0250	.0003	3.4
8484	Feb. 3	Feb. 3	V.slight.	V.slight.	0.30	7.30	1.85	.0070	.0228	.0156	.0072	.69	.0220	.0002	3.6
8573	Mar. 3	Mar. 3	Slight.	Slight.	0.20	7.95	1.45	.0082	.0204	.0182	.0022	.72	.0350	.0000	3.8
8708	Apr. 5	Apr. 5	Slight.	Cons., green.	0.15	7.20	1.80	.0070	.0154	.0126	.0028	.68	.0500	.0002	3.3
8845	May 4	May 4	Slight.	Cons.	0.15	6.95	1.10	.0000	.0208	.0152	.0056	.64	.0400	.0002	3.2
8966	June 6	June 7	Slight.	Cons., white.	0.15	7.25	1.35	.0044	.0166	.0148	.0018	.69	.0300	.0003	3.1
9074	July 6	July 7	Slight.	Cons., earthy	0.12	6.65	1.40	.0012	.0212	.0168	.0044	.63	.0180	.0005	2.7
9188	Aug. 2	Aug. 2	Slight.	Cons., green.	0.10	7.35	1.65	.0016	.0200	.0146	.0054	.65	.0180	.0003	3.5
9349	Sept. 7	Sept. 7	Distinct.	Decided, white.	0.15	6.85	1.50	.0004	.0222	.0176	.0046	.61	.0130	.0003	3.3
9496	Oct. 5	Oct. 5	Slight.	Cons., yellow.	0.10	6.90	2.05	.0066	.0244	.0156	.0088	.62	.0180	.0002	3.6
9641	Nov. 7	Nov. 8	Distinct.	Cons.	0.15	7.50	1.40	.0362	.0212	.0178	.0034	.69	.0150	.0007	4.0
9766	Dec. 6	Dec. 7	Slight.	Cons., rusty.	0.20	7.30	1.60	.0218	.0256	.0166	.0090	.67	.0150	.0003	3.8
Av.	....	....	....	....	0.16	7.23	1.57	.0086	.0210	.0161	.0049	.67	.0249	.0003	3.4

Odor, generally faintly vegetable or none. On heating, the odors were much stronger, generally vegetable and sometimes unpleasant. —— The samples were collected from the pump well at the pumping station. For heights of water in this pond at the times when samples of water were collected for analysis, see page 118.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, Cambridge.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	6	4	9	6	5	8	6	3	9	7	9	8
Number of sample, . .	8390	8484	8573	8708	8845	8966	9074	9188	9349	9496	9641	9766
PLANTS.												
Diatomaceæ, . . .	**2,048**	**232**	**871**	**542**	**1,616**	**989**	**259**	**1,058**	**478**	**669**	**283**	**2,018**
Asterionella, . . .	400	33	68	256	228	412	pr.	0	6	7	0	588
Cyclotella, . . .	90	78	412	72	6	21	96	17	11	56	14	140
Diatoma, . . .	0	1	6	0	0	7	0	3	0	0	100	4
Fragilaria, . . .	4	0	17	4	336	8	15	35	428	320	2	176
Grammatophora, . .	0	0	0	0	0	0	0	0	0	0	15	0
Melosira, . . .	784	24	9	26	95	15	28	82	20	144	127	348
Navicula, . . .	0	0	0	pr.	4	0	0	1	1	1	1	0
Stephanodiscus, . .	616	12	1	40	192	6	1	3	0	64	0	554
Synedra, . . .	53	42	352	130	688	12	3	912	5	5	24	4
Tabellaria, . . .	101	42	6	14	67	508	116	5	7	72	0	204
Cyanophyceæ, . .	**22**	**0**	**0**	**0**	**0**	**3**	**4**	**256**	**188**	**79**	**4**	**2**
Anabæna, . . .	0	0	0	0	0	0	0	1	72	5	0	1
Chroöcoccus, . . .	15	0	0	0	0	0	0	0	0	4	0	0
Clathrocystis, . .	6	0	0	0	0	0	3	16	20	5	0	0
Cœlosphærium, . .	0	0	0	0	0	0	0	3	56	64	4	0
Microcystis, . . .	1	0	0	0	0	3	1	236	40	1	0	1
Algæ, ...	**150**	**22**	**30**	**9**	**22**	**233**	**2**	**53**	**165**	**6**	**3**	**3**
Botrycoccus, . . .	0	0	0	0	0	0	0	0	7	1	0	0
Chlorococcus, . .	0	5	0	0	0	16	0	44	4	0	0	0
Closterium, . . .	146	14	26	8	13	212	1	0	11	1	0	1
Protococcus, . . .	0	0	0	0	0	0	0	0	136	0	0	0
Scenedesmus, . .	4	3	4	1	9	4	0	2	1	0	3	2
Staurastrum, . . .	pr.	0	0	0	0	1	1	5	0	4	0	0
Tetraspora, . . .	0	0	0	0	0	0	0	2	6	0	0	0
Fungi, ...	**68**	**pr.**	**0**	**9**	**0**	**2**	**0**	**0**	**0**	**72**	**2**	**0**
Crenothrix, . . .	68	pr.	0	9	0	2	0	0	0	40	2	0
Molds, ...	0	0	0	0	0	0	0	0	0	32	0	0
ANIMALS.												
Infusoria, . . .	**6**	**3**	**1**	**0**	**4**	**0**	**2**	**5**	**3**	**3**	**2**	**1**
Ceratium, . . .	0	0	0	0	0	0	0	1	3	0	0	0
Chloromonas, . .	0	2	0	0	0	0	0	0	0	0	0	0
Dinobryon cases, . .	0	0	0	0	4	0	0	0	0	0	0	0
Trachelomonas, . .	4	1	1	0	0	0	2	4	0	3	2	1
Vorticella, . . .	2	pr.	0	0	0	0	0	0	0	0	0	0
Vermes. Anuræa, . .	**pr.**	**0**	**0**	**0**	**1**	**2**	**0**	**1**	**0**	**0**	**0**	**0**
Crustacea. Cyclops, .	**.02**	**.01**	**0**	**0**	**.02**	**0**	**.04**	**0**	**0**	**0**	**0**	**0**
Miscellaneous, ...	**74**	**210**	**199**	**248**	**272**	**152**	**272**	**300**	*	**288**	**116**	**104**
Hydra, ...	0	0	0	0	0	0	0	0	*	0	0	0
Acarina, ...	.01	.02	1	.08	0	0	0	.02	0	0	0	0
Zoöglœa, ...	74	210	198	248	272	152	272	300	0	288	116	104
TOTAL, ...	2,368	467	1,101	808	1,915	1,381	539	1,673	834	1,117	410	2,128

* Very abundant.

CAMBRIDGE.

Chemical Examination of Water from Stony Brook Storage Reservoir in Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8396	Jan. 5	Jan. 6	V. slight.	Slight.	0.80	6.55	1.95	.0000	.0210	.0194	.0016	.41	.0500	.0005	2.2
8485	Feb. 3	Feb. 4	V. slight.	None.	0.65	5.80	1.65	.0000	.0164	.0148	.0016	.42	.0450	.0002	2.1
8576	Mar. 3	Mar. 4	V. slight.	Slight.	0.75	4.85	1.65	.0016	.0188	.0168	.0020	.40	.0020	.0001	2.2
8709	Apr. 5	Apr. 6	Distinct, green.	Slight, green.	0.70	4.85	2.15	.0000	.0324	.0268	.0056	.33	.0250	.0000	1.8
8849	May 4	May 5	Slight.	Slight.	0.60	4.90	1.30	.0012	.0214	.0182	.0032	.35	.0260	.0001	2.0
8965	June 6	June 7	Slight.	Cons.	0.95	5.90	1.60	.0000	.0262	.0236	.0026	.30	.0120	.0000	1.7
9072	July 6	July 6	Slight.	Cons., green.	0.85	5.30	2.15	.0000	.0280	.0226	.0054	.34	.0150	.0003	2.1
9192	Aug. 2	Aug. 3	Distinct.	Slight.	0.60	5.15	2.00	.0004	.0306	.0252	.0054	.36	.0000	.0001	2.5
9352	Sept. 7	Sept. 8	Distinct.	Cons., green.	0.50	5.25	2.05	.0002	.0214	.0156	.0058	.38	.0150	.0000	2.1
9497	Oct. 5	Oct. 6	Slight.	Cons., yellow.	0.80	5.30	1.65	.0082	.0254	.0208	.0046	.39	.0050	.0000	2.3
9640	Nov. 7	Nov. 8	Distinct.	Cons., green.	0.50	4.90	1.30	.0050	.0226	.0158	.0068	.43	.0150	.0000	2.6
9769	Dec. 7	Dec. 8	V. slight.	Slight.	1.00	6.40	2.05	.0012	.0244	.0226	.0018	.35	.0400	.0001	3.0
Av.	....	....	....	....	0.72	5.43	1.79	.0015	.0241	.0202	.0039	.37	.0208	.0001	2.2

Odor, generally faintly vegetable, becoming stronger on heating and occasionally mouldy or unpleasant. —— The samples were collected from the reservoir near the surface at the dam. For heights of water in this reservoir at times when samples of water were collected for analysis, see page 118.

CAMBRIDGE.

Microscopical Examination of Water from Stony Brook Storage Reservoir in Waltham.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	4	9	6	5	8	6	3	9	7	9	8
Number of sample,	8396	8485	8576	8709	8849	8965	9072	9192	9352	9497	9640	9769
PLANTS.												
Diatomaceæ,	**493**	**0**	**46**	**49**	**292**	**1,174**	**1,228**	**333**	**406**	**260**	**920**	**241**
Asterionella,	21	0	0	4	12	7	22	0	0	9	33	114
Cyclotella,	5	0	0	6	54	15	15	52	112	11	108	41
Diatoma,	3	0	0	0	2	28	7	0	0	0	76	2
Fragilaria,	2	0	3	7	9	19	8	0	0	0	0	0
Melosira,	1	0	3	2	0	0	0	0	0	0	4	0
Meridion,	0	0	pr.	4	0	0	pr.	0	0	0	1	0
Navicula,	0	0	pr.	2	0	1	pr.	0	42	1	2	pr.
Synedra,	5	0	40	15	126	180	36	5	0	3	4	2
Tabellaria,	456	0	0	9	89	924	1,140	276	252	236	692	82
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**89**	**88**	**88**	**0**	**0**
Anabæna,	0	0	0	0	0	0	pr.	1	68	88	0	0
Clathrocystis,	0	0	0	0	0	0	9	88	20	0	0	0
Algæ,	**4**	**0**	**0**	**8**	**4**	**2**	**54**	**10**	**63**	**85**	**2**	**pr.**
Chlorococcus,	0	0	0	1	0	0	37	0	0	0	0	0
Closterium,	4	0	0	1	0	2	7	0	38	76	0	pr.
Protococcus,	0	0	0	0	0	0	4	0	6	0	0	0
Raphidium,	pr.	0	0	0	3	0	2	6	3	0	0	0
Staurastrum,	pr.	0	0	0	0	0	4	4	16	1	2	0
Zoöspores,	0	0	0	6	1	0	0	0	0	8	0	0
Fungi. Crenothrix,	**2**	**0**	**4**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**pr.**	**0**	**pr.**	**2**	**0**	**4**	**0**	**0**
Actinophrys,	0	0	0	0	pr.	0	pr.	1	0	4	0	0
Difflugia,	0	0	0	0	pr.	0	0	1	0	0	0	0
Infusoria,	**0**	**0**	**pr.**	**45**	**1**	**52**	**17**	**5**	**68**	**26**	**1**	**pr.**
Ceratium,	0	0	0	0	pr.	0	0	1	0	0	0	0
Dinobryon,	0	0	0	40	1	0	12	0	0	13	0	0
Dinobryon cases,	0	0	0	0	0	52	3	0	0	10	0	0
Monas,	0	0	pr.	0	0	0	0	0	pr.	1	0	0
Peridinium,	0	0	0	3	0	0	2	0	56	0	0	0
Synura,	0	0	0	2	pr.	0	0	0	0	0	0	0
Trachelomonas,	0	0	pr.	0	pr.	0	0	4	5	2	1	pr.
Vorticella,	0	0	0	0	0	0	0	0	7	0	0	0
Vermes. Anurea,	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**5**	**1**	**50**	**0**	**104**	**188**	**6**	**0**	**106**	**120**	**48**	**0**
TOTAL,	504	1	100	104	401	1,417	1,374	440	731	583	972	241

CAMBRIDGE.

Table showing Heights of Water in Fresh Pond and Stony Brook Reservoir at the Times when Samples of Water were collected for Analysis.

[Heights are in feet above Cambridge city base.]

FRESH POND. HIGH WATER, 16.85.		STONY BROOK. ROLLWAY, 81.00.	
DATE.	Height of Water.	DATE.	Height of Water.
1892.		1892.	
Jan. 5,	16.05	Jan. 5,	81.42
Feb. 3,	15.87	Feb. 3,	81.36
Mar. 3,	15.36	Mar. 3,	81.28
April 5,	15.72	April 5,	81.45
May 4,	16.17	May 4,	81.25
June 6,	16.58	June 6,	81.22
July 6,	15.86	July 6,	81.15
Aug. 2,	13.43	Aug. 2,	80.89
Sept. 7,	13.59	Sept. 7,	76.27
Oct. 5,	14.09	Oct. 5,	70.79
Nov. 7,	12.50	Nov. 7,	69.90
Dec. 6,	13.62	Dec. 7,	80.23

WATER SUPPLY OF CANTON.

The advice of the State Board of Health to the town of Canton with regard to an additional water supply to be obtained from a well near Henry Springs may be found on page 10 of this volume. The analysis of this water is given below.

Chemical Examination of Water from a Flowing Tubular Well near Henry Springs, Canton.

[Parts per 100,000.]

Number.	DATE OF		APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Hardness.	Iron.
	Collection.	Exam- ination.	Turbidity.	Sediment.	Color.		Free.	Albu- minoid.		Nitrates.	Nitrites.		
	1892.												
8807	Apr. 26	Apr. 27	None.	None.	0.0	3.30	.0000	.0004	.34	.0150	.0000	0.9	-

Odor, none.——The sample was collected during an investigation made with reference to an additional water supply for Canton.

Chelmsford.

Chemical Examination of Water from Deep Brook.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8969	June 6	June 7	Slight.	Slight.	1.60	4.30	2.00	.0000	.0224	.0198	.0026	.12	.0050	.0002	0.5

Odor, distinctly vegetable and musty. —— The sample was collected from the brook at the second road crossing above the Merrimack River, during an investigation for an additional water supply for the city of Lowell.

Water Supply of Chelsea.

(See *Boston, — Mystic Works.*)

Water Supply of Chicopee.

During the year 1892 the city of Chicopee purchased the works of the Chicopee Water Company, which supplies water to the main village of Chicopee, also the newly constructed works of the Willimansett Aqueduct Company, which furnish a water supply to the small village of Willimansett, which lies within the city limits. The city was authorized by chapter 384 of the Acts of 1892 to take the water of certain brooks north of the Chicopee River as sources of water supply for the city. It is the purpose in the beginning to use this new source to replace the present supply of the village of Chicopee Falls, which is now taken from the Chicopee River, and ultimately to extend this new supply to other parts of the city. Plans for the construction of the new works have already been prepared.

The advice of the State Board of Health to the city with regard to these brooks as sources of water supply may be found on page 11 of this volume. The analyses of the waters of these brooks are given below.

CHICOPEE.

Chemical Examination of Water from Morton, Cooley, Higher and School-house Brooks in Chicopee.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8942	May 26	May 27	V. slight.	Cons., earthy.	0.01	3.60	0.75	.0000	.0020	.0008	.0012	.14	.0030	.0000	1.2
8943	May 26	May 27	V. slight.	Cons., earthy.	0.70	4.00	1.60	.0004	.0120	.0088	.0032	.14	.0000	.0000	1.0
8944	May 26	May 27	Slight.	Slight.	0.80	5.10	2.50	.0000	.0210	.0174	.0036	.11	.0000	.0000	1.5
8945	May 26	May 27	Slight.	Cons., earthy.	0.05	3.40	1.25	.0004	.0100	.0040	.0060	.15	.0050	.0001	1.2

Odor of No. 8942, faintly vegetable, disappearing on heating; of No. 8943, none, becoming faintly vegetable on heating; of No. 8944, very faintly vegetable, unchanged by heating; of No. 8945, very faintly vegetable, disappearing on heating.—— No. 8942 was collected from Morton Brook, at a weir about 600 feet above Cooley Brook; No. 8943 from Cooley Brook, at a weir at upper end of flat land, above Morton Brook and about half a mile from the Chicopee River; No. 8944 from Higher Brook, also known as Fuller Brook, at first road crossing above the Chicopee River; No. 8945 from School-house Brook near its mouth. The samples were collected during an investigation for an additional water supply for Chicopee.

Microscopical Examination.

The total number of organisms in these samples was, respectively, 13, 7, 269 and 105 per cubic centimeter.

Water Supply of Clinton.

The advice of the State Board of Health to the town of Clinton with reference to taking East Waushacum Pond in Sterling as an additional source of water supply may be found on page 13 of this volume. An analysis of the water may be found on page 113 of the twenty-third annual report, for the year 1891.

WATER SUPPLY OF CONCORD.

Chemical Examination of Water from Sandy Pond, Lincoln.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8615	Mar. 15	Mar. 16	V. slight.	V. slight.	0.0	2.95	1.35	.0016	.0160	.0132	.0028	.27	.0090	.0000	0.3

Odor, none. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 3; *Tabellaria*, 2. Infusoria, *Dinobryon*, 82; *Dinobryon cases*, 70. Miscellaneous, *Zoöglœa*, 1. Total, 158.

WATER SUPPLY OF COTTAGE CITY. — COTTAGE CITY WATER COMPANY.

Chemical Examination of Water from the Springs of the Cottage City Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8792	Apr 21	Apr. 23	V. slight.	None.	0.04	3.95	.0000	.0000	.90	.0090	.0000	0.5	-
9139	July 21	July 22	V. slight.	V. slight.	0.00	3.70	.0000	.0000	.92	.0000	.0000	0.6	-
9272	Aug. 17	Aug. 18	None.	None.	0.00	3.60	.0000	.0002	.96	.0070	.0000	0.6	.0250
Av.	....	....	....	....	0.01	3.75	.0000	.0001	.93	.0053	.0000	0.6	-

Odor of 9139, very faintly vegetable; of the others, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 8792, Miscellaneous, *Zoöglœa*, 4. No. 9139, Diatomaceæ, *Fragilaria*, 4. No. 9272, Vermes, *Sacculus*, pr.

WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

The following series of examinations of the water supply of Dedham were made to determine the effect of storing the water in the large open iron tank built in 1890. Both the chemical and microscopical examinations show that the water deteriorates when exposed to the light in this way.

DEDHAM.

WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

Chemical Examination of Water from the Well of the Dedham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8467	Jan. 29	Jan. 30	None.	None.	0.0	10.00	.0000	.0002	0.85	.4000	.0000	4.2	–
8550	Feb. 24	Feb. 24	None.	None.	0.0	10.75	.0000	.0016	0.97	.3800	.0000	4.3	–
8660	Mar. 24	Mar. 25	None.	None.	0.0	8.80	.0000	.0004	0.83	.2500	.0000	4.0	–
8864	May 3	May 6	None.	None	0.0	11.45	.0000	.0000	0.94	.3000	.0000	4.0	–
8932	May 26	May 26	None.	None.	0.0	10.60	.0000	.0000	0.95	.3250	.0001	4.3	–
9030	June 22	June 23	None.	None.	0.0	13.55	.0002	.0006	1.09	.2750	.0000	5.0	–
9176	July 30	Aug. 2	None.	None.	0.0	11.45	.0000	.0004	0.88	.2440	.0000	4.3	–
9304	Aug. 25	Aug. 25	None.	None.	0.0	11.90	.0000	.0000	1.14	.3000	.0000	4.9	.0025
9440	Sept. 26	Sept. 27	None.	None.	0.0	9.75	.0000	.0004	0.93	.2000	.0001	4.1	.0000
9581	Oct. 27	Oct. 28	None.	None.	0.0	9.95	.0000	.0000	0.94	.2300	.0001	4.2	.0000
9706	Nov. 22	Nov. 23	None.	None.	0.0	9.55	.0000	.0010	0.90	.3500	.0000	4.7	.0010
9816	Dec. 20	Dec. 21	None.	None.	0.0	10.05	.0000	.0024	0.96	.3250	.0000	5.0	.0000
Av.	....	....	....	....	0.0	10.65	.0000	.0006	0.95	.2982	.0000	4.4	.0007

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Well of the Dedham Water Company.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	May.	May.	June.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	25	25	7	26	23	2	26	28	28	23	21
Number of sample,	8467	8550	8660	8864	8932	9030	9176	9304	9440	9581	9706	9816
PLANTS.												
Diatomaceæ,	**0**	**2**	**3**	**0**	**2**	**3**	**0**	**0**	**1**	**2**	**0**	**2**
Asterionella,	0	1	2	0	2	3	0	0	1	0	0	0
Diatoma,	0	1	1	0	0	0	0	0	0	2	0	2
Algæ. Spirogyra,	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL,	0	2	3	0	10	3	0	0	1	2	0	2

DEDHAM.

Chemical Examination of Water from the New Open Tank of the Dedham Water Company, on Federal Hill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8466	Jan. 29	Jan. 30	V. slight.	V. slight	0.00	10.25	.0000	.0020	.85	.4000	.0001	4.3	–
8549	Feb. 24	Feb. 24	V. slight.	V. slight.	0.00	11.15	.0000	.0038	.95	.3500	.0000	4.3	–
8659	Mar. 24	Mar. 25	V. slight.	V. slight	0.00	10.00	.0000	.0048	.95	.4000	.0001	4.6	–
8865	May 3	May 6	Distinct, green	Cons., green.	0.00	10.50	.0020	.0068	.94	.3000	.0001	4.0	–
8933	May 26	May 26	Slight.	Cons.	0.03	11.65	.0000	.0044	.97	.3250	.0001	4.3	–
9031	June 22	June 23	Slight.	Slight.	0.02	12.15	.0000	.0050	.94	.2000	.0001	4.7	–
9175	July 30	Aug. 2	V. slight.	V. slight.	0.00	11.75	.0004	.0010	.90	.2500	.0002	4.3	–
9303	Aug. 25	Aug. 25	V. slight.	V. slight.	0.00	9.80	.0000	.0040	.90	.2000	.0001	4.3	.0400
9439	Sept. 26	Sept. 27	Distinct.	Cons., yellow.	0.02	10.90	.0000	.0084	.93	.2000	.0001	4.3	.0050
9580	Oct. 27	Oct. 28	V. slight.	Slight.	0.02	10.35	.0000	.0050	.90	.2300	.0000	4.5	.0010
9707	Nov. 22	Nov. 23	Distinct.	Slight.	0.02	10.50	.0002	.0148	.93	.3750	.0000	4.7	.0060
9815	Dec. 20	Dec. 21	None.	None.	0.00	10.60	.0000	.0054	.95	.3250	.0000	5.0	.0020
Av.	....	....	....	....	0.01	10.80	.0002	.0054	.93	.2962	.0001	4.4	.0108

Odor of 8865, faintly vegetable; of 9175, faintly disagreeable; of all others, none. On heating, a faint odor was detected in most cases. —— The samples were collected from the tank. This tank is forty-two feet in diameter and fifty one feet high, and is not covered.

Microscopical Examination of Water from the New Open Tank of the Dedham Water Company, on Federal Hill.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	May.	May.	June.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	25	25	7	26	23	1	26	28	28	23	21
Number of sample,	8466	8549	8659	8865	8933	9031	9175	9303	9439	9580	9707	9815
PLANTS.												
Diatomaceæ,	**358**	**448**	**359**	**11,427**	**3,539**	**1,158**	**112**	**512**	**2,528**	**1,408**	**1,030**	**312**
Asterionella,	0	0	5	0	1,662	0	pr.	0	1,296	0	0	0
Cyclotella,	0	0	0	1	1,864	0	0	0	0	0	0	0
Cymbella,	0	0	0	0	0	1,156	0	0	0	0	0	0
Diatoma,	358	216	354	11,392	0	0	10	80	0	802	818	118
Fragilaria,	0	0	0	8	13	0	0	426	1,232	606	212	140
Synedra,	pr.	232	5	26	0	2	102	6	0	0	0	[illegible]
Algæ,	**0**	**36**	**pr.**	**8**	**6**	**44**	**0**	**0**	**0**	**10**	**7**	**0**
Chlorococcus,	0	36	pr.	8	6	44	0	0	0	0	0	0
Dictyosphærium,	0	0	0	0	0	0	0	0	0	10	0	0
Protococcus,	0	0	0	0	0	0	0	0	0	0	7	0

DEDHAM.

Microscopical Examination of Water from the New Open Tank of the Dedham Water Company, on Federal Hill — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	**0**	**0**	**40**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Disintegrated infusoria,	0	0	40	0	0	0	0	0	0	0	0	0
Gonium,	0	0	0	4	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**0**	**1**	**0**	**0**	**0**	**0**	**6**	**3**	*	**0**	**1**	**0**
TOTAL,	358	485	399	11,439	3,545	1,202	118	515	2,528	1,418	1,038	312

* Abundant.

WATER SUPPLY OF NORTH EASTON VILLAGE DISTRICT, EASTON.

Chemical Examination of Water from the Well of the North Easton Village District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8435	Jan. 19	Jan. 20	None.	None.	0.0	4.60	.0000	.0000	.37	.0700	.0001	1.3	-
8511	Feb. 15	Feb. 16	None.	None.	0.0	3.60	.0000	.0006	.40	.0650	.0000	0.9	-
8608	Mar. 10	Mar. 11	None.	None.	0.0	3.50	.0000	.0006	.42	.0700	.0000	1.4	-
8714	Apr. 5	Apr. 6	None.	None.	0.0	3.85	.0000	.0000	.41	.0550	.0000	1.4	-
8860	May 4	May 6	None.	None.	0.0	3.50	.0000	.0000	.40	.0550	.0000	1.3	-
8967	June 6	June 7	None.	None.	0.0	3.65	.0000	.0000	.43	.0300	.0000	0.8	-
9076	July 6	July 7	None.	None.	0.0	3.60	.0000	.0022	.40	.0200	.0000	1.4	-
9195	Aug. 2	Aug. 3	None.	None.	0.0	3.85	.0004	.0006	.44	.0200	.0000	1.7	.0029
9353	Sept. 7	Sept. 8	None.	None.	0.0	3.45	.0000	.0000	.44	.0300	.0000	1.4	.0065
9498	Oct. 5	Oct. 6	None.	None.	0.0	4.00	.0000	.0026	.46	.0100	.0000	1.3	.0025
9646	Nov. 7	Nov. 9	None.	None.	0.0	3.90	.0002	.0000	.45	.0350	.0000	1.8	.0010
9761	Dec. 5	Dec. 6	None.	None.	0.0	3.60	.0008	.0004	.47	.0450	.0000	1.8	.0070
Av.	....	....	....	....	0.0	3.76	.0001	.0006	.42	.0421	.0000	1.4	.0040

Odor, none. —— The samples were collected either from the well or from a faucet at the pumping station while pumping.

Microscopical Examination.

At times there is an insignificant number of organisms in this water, but generally none.

Water Supply of Everett.

(See *Boston, Mystic Works.*)

Water Supply of Fall River.

Chemical Examination of Water from North Watuppa Lake.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8436	Jan. 20	Jan. 21	Slight.	Slight.	0.08	2.70	0.90	.0000	.0100	.0054	.0046	.49	.0050	.0000	0.5
8825	Apr. 28	Apr. 29	None.	V. slight.	0.07	3.00	0.90	.0046	.0108	.0106	.0002	.51	.0250	.0003	0.6
9159	July 27	July 28	Slight.	Cons.	0.10	3.05	0.90	.0002	.0184	.0152	.0032	.53	.0080	.0001	0.3
9572	Oct. 26	Oct. 27	Slight.	Slight.	0.07	3.05	0.75	.0000	.0128	.0116	.0012	.57	.0090	.0001	0.6
Av.	....	....	....	....	0.08	2.95	0.86	.0012	.0130	.0107	.0023	.52	.0117	.0001	0.5

Odor, faintly vegetable.—— Nos. 8436 and 9159 were collected from a faucet in the repair shop on Rock Street; the others were collected from a faucet at the pumping station.

Microscopical Examination of Water from North Watuppa Lake.

[Number of organisms per cubic centimeter.]

	1892. January.	April.	July.	October.
Day of examination,	21	30	28	27
Number of sample,	8436	8825	9159	9572
PLANTS.				
Diatomaceæ,	124	8	22	pr.
Asterionella,	2	1	0	0
Cyclotella,	82	4	6	pr.
Diatoma,	2	0	4	0
Fragilaria,	2	0	0	0
Grammatophora,	0	0	8	0
Navicula,	0	0	2	0
Synedra,	36	3	2	0
Cyanophyceæ,	pr.	0	18	pr.
Merismopedia,	0	0	16	0
Microcystis,	pr.	0	2	pr.
Algæ,	28	pr.	214	0
Chlorococcus,	28	pr.	206	0
Conferva,	0	0	2	0
Cosmarium,	0	0	6	0
Fungi. Crenothrix,	pr.	0	6	0

FALL RIVER.

Microscopical Examination of Water from North Watuppa Lake — Concluded.

[Number of organisms per cubic centimeter.]

	1892.			
	January.	April.	July.	October.
ANIMALS.				
Rhizopoda. Difflugia,	0	pr.	0	0
Infusoria,	0	1	pr.	pr.
Dinobryon cases,	0	1	0	0
Peridinium,	0	0	pr.	pr.
Vermes. Anurea,	0	0	0	pr.
Miscellaneous. Zoöglœa,	24	0	502	0
TOTAL,	176	9	762	pr.

WATER SUPPLY OF FITCHBURG.

During the autumn of 1891 the reservoirs of the Fitchburg water works were drawn to a very low point, and active measures were taken to secure an additional water supply. The city obtained from the Legislature an act to enable it to take the waters of Meeting-house Pond and Wachusett Lake, situated in Westminster, about seven miles south-westerly from the centre of the city, as sources of water supply, and to take, in addition, the waters of Wyman's Reservoir, so called, for the purpose of constructing a compensating reservoir to supply water to the mills further down the stream. The advice of the State Board of Health with regard to these sources is contained in the annual report of the Board, for the year 1891, page 27.

Above the dam of Wyman's Reservoir there is a total watershed of 7.73 square miles, including water surfaces, and within this watershed are located both of the ponds from which the city is authorized to take a supply. A pipe was laid in 1892 for taking water from Meeting-house Pond, and it is so located that by building a comparatively short branch to Wachusett Lake this source will also be made available. The pipe passes through the dam of Wyman's Reservoir at a sufficient height to supply the whole city of Fitchburg by gravity, so that it will also be possible, when a further supply is required, to take water from any other part of the watershed above Wyman's dam from which a satisfactory water can be obtained. Meeting-house Pond has an area of 152.3 acres and

a watershed of 1.47 square miles, including the area of the pond. The character of the watershed and of the shores of the pond are both favorable for furnishing an excellent quality of water. There is, however, a wood-working factory located near the main feeder of the pond, and a small settlement in its vicinity. The pipe line is not carried all the way from the city to the pond, but ends at a small reservoir which was formerly a millpond on the brook which flows from Meeting-house Pond and about a mile from it. This reservoir is a small one, covering only a little over half an acre, and it is about ten feet in depth at the dam. Wachusett Lake, to which the pipe has not yet been extended, has an area of 134.15 acres and a watershed of 1.53 square miles, which has very little population upon it, and consists in part of the steep northerly slope of Wachusett Mountain.

Chemical Examination of Water from Scott Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1892.														
8454	Jan. 28	Jan. 29	Slight.	Slight.	0.30	3.10	1.15	.0010	.0144	.0104	.0040	.18	.0120	.0001	0.3
8520	Feb. 16	Feb. 18	Distinct.	Cons., green.	0.20	2.90	1.25	.0008	.0262	.0122	.0140	.18	.0180	.0001	0.6
8650	Mar. 22	Mar. 23	Slight.	V. slight.	0.10	3.05	1.25	.0010	.0282	.0222	.0060	.24	.0100	.0000	0.8
8803	Apr. 25	Apr. 26	Slight.	V. slight.	0.08	2.45	0.90	.0000	.0162	.0128	.0034	.14	.0090	.0000	0.2
8925	May 23	May 24	Slight.	Cons., white.	0.08	2.35	0.90	.0000	.0232	.0170	.0062	.17	.0070	.0000	0.3
9035	June 27	June 28	Distinct.	Cons., white.	0.10	2.50	1.25	.0004	.0226	.0174	.0052	.16	.0050	.0000	0.5
9164	July 27	July 28	Distinct.	Cons.	0.08	3.40	1.35	.0004	.0230	.0210	.0020	.19	.0100	.0000	0.3
9291	Aug. 22	Aug. 24	Distinct.	Cons.	0.15	3.35	1.60	.0010	.0286	.0236	.0050	.17	.0000	.0002	0.6
9469	Sept. 29	Sept. 30	Distinct.	Slight., yellow.	0.15	2.55	1.30	.0006	.0318	.0246	.0072	.18	.0280	.0000	0.7
9612	Nov. 1	Nov. 3	Distinct.	Cons.	0.10	2.40	0.85	.0000	.0350	.0250	.0100	.16	.0000	.0000	0.2
9732	Nov. 28	Nov. 29	Distinct.	Slight.	0.10	2.35	1.00	.0000	.0354	.0270	.0084	.16	.0050	.0001	0.8
9814	Dec. 20	Dec. 21	Distinct.	Slight., sand.	0.12	3.00	1.15	.0010	.0282	.0246	.0036	.18	.0030	.0000	0.8
Av.	....	....	....	....	0.13	2.78	1.16	.0005	.0261	.0198	.0063	.18	.0089	.0000	0.5

Odor, vegetable, frequently unpleasant or disagreeable. —— The samples were collected from the reservoir at the gate house, one foot beneath the surface.

FITCHBURG.

Microscopical Examination of Water from Scott Reservoir, Fitchburg.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Nov.	Dec.
Day of examination,	30	18	23	27	25	29	28	25	30	3	30	21
Number of sample,	8454	8520	8650	8803	8925	9035	9164	9291	9469	9612	9732	9814
PLANTS.												
Diatomaceæ,	**21**	**14**	**5**	**137**	**526**	**928**	**65**	**2,053**	**770**	**936**	**2,793**	**49**
Asterionella,	2	0	0	108	112	414	49	130	264	112	18	5
Cyclotella,	0	0	4	3	2	4	0	0	0	0	0	0
Melosira,	0	0	0	10	6	9	1	0	148	304	36	12
Synedra,	17	12	1	7	370	464	15	1,916	2	192	2,652	22
Tabellaria,	2	2	0	9	36	37	0	7	356	328	87	10
Cyanophyceæ. Anabæna,	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**116**	**0**	**0**	**0**
Algæ,	**1**	**49**	**52**	**67**	**251**	**6**	**3**	**140**	**64**	**784**	**68**	**268**
Chlorococcus,	pr.	0	0	5	139	0	0	2	2	50	0	0
Closterium,	1	5	38	0	0	0	0	0	0	0	0	0
Conferva,	0	0	0	0	0	0	0	0	0	288	0	264
Dictyosphærium,	0	0	0	8	5	0	0	0	0	128	0	0
Raphidium,	0	0	0	0	15	1	0	4	0	0	0	0
Scenedesmus,	0	0	0	0	20	0	0	pr.	6	0	0	0
Staurastrum,	0	0	0	pr.	32	5	3	84	56	312	68	3
Tetraspora,	pr.	0	0	pr.	40	0	0	0	0	6	0	0
Zoöspores,	pr.	44	14	54	0	0	0	50	0	0	0	1
Fungi,	**pr.**	**6**	**0**	**1**	**2**	**1**	**0**	**2**	**13**	**0**	**0**	**0**
Crenothrix,	pr.	6	0	1	2	1	0	2	3	0	0	0
Molds,	0	0	0	0	0	0	0	0	10	0	0	0
ANIMALS.												
Rhizopoda,	**1**	**pr.**	**0**	**2**	**36**	**0**	**0**	**pr.**	**0**	**2**	**0**	**0**
Actinophrys,	1	pr.	0	2	36	0	0	0	0	0	0	0
Difflugia,	0	0	0	0	pr.	0	0	pr.	0	2	0	0
Infusoria,	**5**	**192**	**56**	**180**	**184**	**4**	**87**	**272**	**24**	**70**	**9**	**21**
Chloromonas,	0	0	0	0	0	0	0	0	0	2	0	0
Disintegrated infusoria,	0	0	0	pr.	0	0	1	0	0	0	0	0
Dinobryon,	1	5	8	8	92	0	0	0	0	34	0	15
Dinobryon cases,	0	1	0	170	86	0	68	0	0	0	0	3
Gonium,	0	0	3	0	0	0	0	0	0	0	0	0
Monas,	1	0	0	pr.	0	0	0	pr.	13	0	0	0
Peridinium,	3	186	42	0	6	4	18	272	1	30	5	3
Peridinium cases,	0	0	0	0	0	0	0	0	9	0	0	0
Podophrys,	0	0	0	2	0	0	0	0	0	0	0	0
Synura,	0	0	3	0	0	0	0	0	0	0	1	0
Trachelomonas,	0	0	pr.	0	0	0	0	pr.	1	4	3	0
Vermes,	**3**	**5**	**1**	**5**	**1**	**3**	**3**	**1**	**1**	**0**	**0**	**0**
Anurea,	0	0	0	5	0	0	2	pr.	0	0	0	0
Asplanchna,	pr.	0	0	0	0	0	1	0	0	0	0	0
Monocerca,	0	0	0	0	1	0	0	pr.	0	0	0	0
Polyarthra,	3	5	1	0	0	1	0	1	0	0	0	0
Rotatorian ova,	0	pr.	pr.	0	pr.	2	0	0	1	0	0	0
Miscellaneous. Zoöglœa,	**11**	**42**	**0**	**64**	**88**	**7**	**3**	**264**	*	**8**	**80**	**0**
TOTAL,	42	308	114	456	1,088	949	161	2,732	988	1,800	2,950	338

* Very abundant.

FITCHBURG.

Table showing the Heights of Water in Scott Reservoir on the Dates when Samples of Water were collected for Analysis.

NOTE. — High-water mark is 40 feet.

Date.	Height of Water.	Date.	Height of Water.
	Feet.		Feet.
Jan. 28,	28.5	July 27,	38.7
Feb. 16,	30.0	Aug. 22,	32.7
Mar. 22,	34.0	Sept. 29,	32.4
April 26,	36.5	Nov. 1,	23.0
May 23,	38.3	Nov. 28,	26.0
June 27,	39.0	Dec. 20,	30.0

WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT, FOXBOROUGH.

Chemical Examination of Water from the Tubular Wells of the Foxborough Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8530	Feb. 18	Feb. 19	None.	None.	0.0	3.70	.0000	.0006	.31	.0280	.0000	1.0	-
8744	Apr. 18	Apr. 19	None.	None.	0.0	3.20	.0006	.0002	.30	.0400	.0000	0.6	-
8893	May 14	May 14	None.	None.	0.0	2.95	.0000	.0000	.30	.0400	.0000	1.0	-
9033	June 23	June 23	None.	None.	0.0	3.40	.0010	.0006	.32	.0380	.0000	0.5	-
9119	July 16	July 18	None.	None.	0.0	3.15	.0002	.0004	.31	.0150	.0001	0.6	-
9278	Aug. 19	Aug. 20	None.	None.	0.0	2.65	.0000	.0000	.30	.0180	.0000	1.1	.0200
9423	Sept. 22	Sept. 23	None.	None.	0.0	3.20	.0004	.0000	.31	.0380	.0000	0.6	.0040
9570	Oct. 26	Oct. 26	None.	None.	0.0	2.95	.0000	.0006	.29	.0400	.0000	0.6	.0090
9683	Nov. 16	Nov. 17	None.	None.	0.0	3.70	.0000	.0000	.29	.0300	.0000	0.8	.0050
9802	Dec. 15	Dec. 15	None.	None.	0.0	3.10	.0008	.0006	.29	.0500	.0000	1.0	.0050
Av.					0.0	3.20	.0003	.0003	.30	.0337	.0000	0.8	.0086

Odor, none. —— The samples were collected from a faucet in the pumping station while pumping.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 58 in July and 24 in November.

FOXBOROUGH.

Chemical Examination of Water from the Neponset Reservoir, Foxborough.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8745	Apr. 18	Apr. 19	Distinct.	Slight.	0.45	2.65	1.40	.0010	.0246	.0208	.0038	.26	.0020	.0001	0.0

Odor, vegetable and mouldy. —— The sample was collected from the reservoir at the dam.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 4; *Synedra*, 7; *Tabellaria*, 7. Algæ, *Raphidium*, 4. Rhizopoda, *Difflugia*, 1. Infusoria, *Codonella*, 1; *Dinobryon*, 29; *Dinobryon cases*, 8; *Peridinium*, 29; *Uroglena*, 12. Miscellaneous, *Zoōglœa*, 6. Total, 108.

Water Supply of Framingham. — Framingham Water Company.

Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.

[Parts per 100,000.]

	Date of		Appearance.				Ammonia.			Nitrogen as			
Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albu-minoid.	Chlorine.	Nitrates	Nitrites.	Hardness.	Iron.
	1892.												
9512	Oct. 10	Oct. 12	Distinct, milky.	Slight, rusty.	0.25	5.60	.0074	.0102	.35	.0050	.0025	2.9	.0750
9513	Oct. 10	Oct. 12	None.	Slight, brown.	0.00	5.25	.0028	.0060	.42	.0400	.0010	2.3	.0130

Odor, none. —— The first sample was collected from the southerly portion of the filter-gallery, and the second from the northerly portion.

Microscopical Examination.

No. 9512. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 5. Miscellaneous, *Zoōglœa*, 80. Total, 86.
No. 9513. Fungi, *Crenothrix*, pr.; *Fungus*, 21. Total, 21.

FRAMINGHAM.

Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.

NOTE. — These analyses were made by the city of Boston.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites	Hardness.
	1892.												
	Jan. 14	Jan. 15	Distinct.	Cons.	.00	19.90	3.40	.0720	.0060	3.30	.5500	.0023	7.6
	Feb. 22	Feb. 23	Slight.	Cons.	.01	16.90	1.50	.0880	.0050	3.55	.6000	.0016	7.6
	Mar. 14	Mar. 15	V. slight.	Cons.	.00	17.30	3.50	.0920	.0040	3.25	.5500	.0012	7.9
	Apr. 14	Apr. 15	V. slight.	Slight.	.00	18.70	2.40	.0960	.0030	3.80	.6500	.0015	7.9
	May 16	May 17	Slight.	Cons.	.00	18.20	2.90	.0760	.0030	4.05	.9500	.0015	7.0
	June 14	June 14	V. slight.	Slight.	.01	19.00	4.80	.0840	.0030	4.40	1.0000	.0012	7.4
	July 14	July 15	V. slight.	Slight.	.00	18.90	4.10	.1020	.0070	4.52	.7000	.0020	8.5
	Aug. 15	Aug. 16	Slight.	Slight.	.01	21.00	3.30	.0720	.0030	4.70	.6000	.0014	9.0
	Sept. 14	Sept. 15	Slight.	Cons.	.01	20.10	2.10	.0720	.0040	4.45	.7500	.0025	8.8
	Oct. 14	Oct. 15	Distinct.	Much.	.01	21.70	5.30	.0600	.0040	4.05	.5500	.0030	8.5
	Nov. 14	Nov. 15	Distinct.	Much.	.02	19.70	1.80	.0640	.0060	3.90	.5750	.0020	8.6
	Dec. 14	Dec. 15	V. slight.	Cons.	.02	20.50	3.10	.0960	.0020	3.90	.5250	.0016	7.3
Av.	....	....	....	....	.01	19.32	3.18	.0805	.0042	3.99	.6667	.0018	8.0

Odor, generally faintly musty or mouldy, occasionally vegetable or earthy, very rarely none. —— The samples were collected from the underdrain at its outlet.

NOTE. —— The analyses of Framingham sewage and effluent corresponding to those which were published in this place in the report of last year will be found in a subsequent portion of this report.

FRANKLIN.

WATER SUPPLY OF FRANKLIN. — FRANKLIN WATER COMPANY.

Chemical Examination of Water from the Works of the Franklin Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.	1892.											
8551	Feb. 24	Feb. 25	Slight.	Slight.	0.30	7.40	.0000	*.0132 .0104	0.62	.1600	.0000	2.6	-
8654	Mar. 23	Mar. 24	None.	Slight, rusty.	0.15	6.55	.0000	*.0090 .0058	0.67	.1800	.0000	3.1	-
8921	May 24	May 24	V. slight.	Slight.	0.00	10.60	.0000	.0000	1.01	.3500	.0006	4.2	-
9122	July 19	July 19	None.	None.	0.00	9.80	.0002	.0000	1.04	.3000	.0001	3.9	-
9391	Sept. 19	Sept. 20	None.	None.	0.00	9.90	.0000	.0006	1.00	.3000	.0001	4.0	.0075
9698	Nov. 21	Nov. 22	Distinct, fibrous.	Cons., sandy.	0.00	10.95	.0000	.0014	1.17	.2940	.0000	5.1	.0050
Av.	....	....	....	....	0.07	9.20	.0000	.0040	0.92	.2640	.0001	3.8	-

Odor of No. 8551, vegetable and unpleasant; of 8654, faintly vegetable; of all others, none. —— The samples were collected from a faucet in the town, with the exception of the last two, which were collected from a faucet at the pumping station. The first two samples were evidently wholly or in part surface water.

Microscopical Examination.

The number of organisms in these samples varied from 0 to 113 per cubic centimeter.

* These determinations were made upon the water before filtration through filter-paper.

WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

Chemical Examination of Water from Crystal Lake, Gardner.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8633	Mar. 16	Mar. 17	V. slight.	None.	0.02	2.45	0.65	.0008	.0104	.0086	.0018	.27	.0180	.0000	1.1

Odor, none. —— The sample was collected from the lake.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 9; *Fragilaria*, 2; *Synedra*, 18. Infusoria, *Dinobryon*, 27; *Dinobryon cases*, 74. Total, 130.

GLOUCESTER.

Water Supply of Gloucester. — Gloucester Water Company.

Chemical Examination of Water from Dike's Brook Storage Reservoir, and Wallace Pond, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8404	Jan. 7	Jan. 7	Slight.	Slight.	0.40	4.20	1.80	.0000	.0178	.0150	.0028	.90	.0200	.0000	0.2
8486	Feb. 4	Feb. 5	V.slight.	V.slight.	0.35	4.90	1.80	.0004	.0134	.0120	.0014	1.01	.0350	.0001	0.5
8584	Mar. 7	Mar. 8	V.slight.	V.slight.	0.65	4.00	1.80	.0028	.0192	.0172	.0020	.89	.0070	.0002	0.3
8734	Apr. 13	Apr. 13	V.slight.	V.slight.	0.25	4.00	1.00	.0000	.0166	.0134	.0032	.91	.0060	.0001	0.8
8897	May 16	May 17	V.slight.	V.slight.	0.20	3.65	1.25	.0002	.0124	.0100	.0024	.86	.0150	.0000	0.5
8978	June 8	June 9	Slight.	Slight.	0.55	4.20	1.15	.0086	.0168	.0128	.0040	.96	.0050	.0002	0.5
9081	July 11	July 12	Slight.	Slight.	0.50	4.05	1.35	.0032	.0184	.0160	.0024	.85	.0030	.0000	0.8
9208	Aug. 8	Aug. 8	Slight.	Slight, rusty.	0.65	4.60	1.65	.0068	.0240	.0202	.0038	.93	.0050	.0001	0.6
9356	Sept. 12	Sept. 13	Distinct, green.	Slight.	0.50	4.40	1.65	.0000	.0258	.0194	.0064	.85	.0050	.0002	1.6
9505	Oct. 10	Oct. 11	V.slight.	Slight.	0.55	4.20	1.55	.0030	.0244	.0198	.0046	.86	.0000	.0001	0.7
9663	Nov. 11	Nov. 12	V.slight.	V.slight	0.50	3.90	1.25	.0000	.0140	.0118	.0022	.89	.0200	.0000	0.5
9781	Dec. 12	Dec. 13	None.	V.slight.	0.55	4.30	1.55	.0018	.0256	.0182	.0074	.93	.0200	.0001	1.2
Av.	....	.. ..	....	....	0.47	4.20	1.48	.0022	.0190	.0155	.0035	.90	.0117	.0001	0.7

Odor, generally faintly vegetable, sometimes mouldy or unpleasant. On heating, the vegetable odor usually becomes much stronger. —— The samples were collected from a faucet at the pumping station. The samples collected in January and February, and also those from July to November, inclusive, were from Dike's Brook reservoir; all others were from Wallace Pond.

Microscopical Examination of Water from Dike's Brook Storage Reservoir, and Wallace Pond, Gloucester.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	8	5	10	14	17	9	12	9	13	12	12	13
Number of sample,	8404	8486	8584	8734	8897	8978	9081	9208	9356	9505	9663	9781
PLANTS.												
Diatomaceæ,	171	21	pr.	2	11	55	3	152	11	0	pr.	52
Asterionella,	2	0	0	1	3	37	2	104	0	0	0	17
Diatoma,	pr.	0	0	0	0	0	0	2	1	0	0	5
Melosira,	13	3	0	1	1	0	0	0	0	0	0	7
Synedra,	156	18	pr.	0	7	0	1	46	10	0	pr.	0
Tabellaria,	pr.	pr.	0	0	0	18	0	0	0	0	pr.	23

GLOUCESTER.

Microscopical Examination of Water from Dike's Brook Storage Reservoir, and Wallace Pond, Gloucester — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	**2**	**2**	**180**	**31**	**0**	**4**	**11**	**62**	**2**	**19**	**208**	**0**
Botrycoccus,	0	0	0	0	0	1	8	0	0	pr.	0	0
Chlorococcus,	0	0	0	0	0	3	3	62	2	3	48	0
Protococcus,	0	0	0	0	0	0	0	0	0	16	160	0
Zoöspores,	2	2	180	31	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	**8**	**0**	**1**	**0**	**0**	**3**	**5**	**2**	**108**	**0**	**0**	**4**
ANIMALS.												
Infusoria,	**101**	**4**	**5**	**68**	**40**	**2**	**pr.**	**36**	**11**	**pr.**	**2**	**6**
Dinobryon,	35	0	0	0	0	0	0	0	1	0	0	2
Dinobryon cases,	6	0	0	0	40	1	0	36	5	0	0	0
Peridinium,	60	2	5	68	0	0	0	0	1	0	0	4
Trachelomonas,	0	2	0	0	0	1	pr.	0	4	pr.	2	pr.
Vermes. Anurea,	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Crustacea. Cyclops,	**0**	**0**	**.06**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**1**	**5**	**44**	**pr.**	**0**	**1**	**44**	**30**	**204**	**0**	**35**	**18**
TOTAL,	283	32	230	101	51	65	63	282	336	19	245	80

WATER SUPPLY OF GRAFTON.—GRAFTON WATER COMPANY.

Chemical Examination of Water from the Filter-gallery of the Grafton Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8740	Apr. 14	Apr. 15	None.	None.	0.0	10.30	.0000	.0010	1.63	.5000	.0000	4.3	-
9053	June 30	July 1	None.	None.	0.0	11.40	.0000	.0018	1.62	.1500	.0001	3.8	-
9309	Aug. 25	Aug. 25	None.	None.	0.0	9.30	.0000	.0000	1.12	.1900	.0000	3.8	.0200
9594	Oct. 30	Nov. 1	None.	None.	0.0	10.00	.0000	.0000	1.27	.2100	.0001	3.9	.0000
Av.	....	....	....	....	0.0	10.25	.0000	.0007	1.41	.2625	.0000	3.9	-

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

GRAFTON.

Chemical Examination of Water from a Tubular Well of the Grafton Water Company.

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9054	June 30	July 1	None.	Slight, rusty.	0.05	11.15	.0000	.0052	1.41	.2440	.0002	4.4	–
9308	Aug. 25	Aug. 25	Slight, clayey.	V. slight.	0.10	11.95	.0000	.0018	1.49	.1900	.0003	5.1	.0600
9595	Oct. 30	Nov. 1	None.	V. slight.	0.08	12.15	.0000	.0022	1.32	.2200	.0001	5.0	.0040
Av..	....	....	....	....	0.08	11.75	.0000	.0031	1.41	.2180	.0002	4.8	.0320

Odor, none. —— The samples were collected from the discharge pipe of a pump drawing water from the well.

Microscopical Examination.

No organisms.

Water Supply of Haverhill.

Chemical Examination of Water from Crystal Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9108	July 14	July 15	V. slight.	Slight.	0.13	2.90	1.05	.0004	.0150	.0128	.0022	.24	.0030	.0000	0.6
9109	July 14	July 15	V. slight.	Slight.	0.20	3.05	1.10	.0018	.0188	.0184	.0004	.24	.0050	.0001	1.4

Odor, vegetable and unpleasant. —— The first sample was collected from near the middle of the lake; the last was collected at the gate-house, where water enters the pipe to the city.

Microscopical Examination.

No. 9108. Diatomaceæ, *Navicula*, 1; *Tabellaria*, 8. Cyanophyceæ, *Anabæna*, 2; *Cœlosphærium*, 3. Algæ, *Staurastrum*, 2; *Xanthidium*, 1. Infusoria, *Dinobryon cases*, 1; *Peridinium*, 1; Vermes, *Polyarthra*, 1. Total, 20.

No. 9109. Diatomaceæ, *Asterionella*, 1; *Stauroneis*, 1; *Synedra*, 2; *Tabellaria*, 2. Cyanophyceæ, *Cœlosphærium*, 2. Algæ, *Cosmarium*, 1. Total, 9.

HAVERHILL.

Chemical Examination of Water from Lake Pentucket, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9010	June 15	June 16	V. slight.	Cons.	0.00	3.60	1.05	.0000	.0164	.0136	.0028	.40	.0050	.0000	1.4
9156	July 27	July 28	Slight.	Cons., rusty.	0.05	4.20	1.35	.0004	.0172	.0154	.0018	.33	.0020	.0001	1.8

Odor, vegetable. —— The samples were collected from a faucet in the office of the Haverhill water works, supplied from Lake Pentucket. At the time the last sample was collected water was being pumped into this lake from Kenoza Lake.

Microscopical Examination.

No. 9010. Diatomaceæ, *Cyclotella*, 1; *Fragilaria*, 1; *Synedra*, 1. Cyanophyceæ, *Anabæna*, 1; *Chroöcoccus*, 4. Algæ, *Chlorococcus*, 12; *Desmidium*, 7. Infusoria, *Vorticella*, 4. Vermes, *Sacculus*, 1. Miscellaneous, *Zoöglœa*, 124. Total, 156.

No. 9156. Diatomaceæ, *Navicula*, 1. Algæ, *Raphidium*, 8; *Staurastrum*, 1. Miscellaneous, *Zoöglœa*, 39. Total, 49.

Chemical Examination of Water from Lake Saltonstall, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9009	June 15	June 16	V. slight	Cons.	0.00	5.25	1.05	.0000	.0166	.0138	.0028	.66	.0000	.0000	1.9
9157	July 27	July 28	Slight.	Cons., rusty.	0.02	5.45	1.45	.0000	.0200	.0156	.0044	.62	.0020	.0001	2.5

Odor of 9009, faintly vegetable and mouldy; of 9157, decidedly vegetable. —— The samples were collected from a faucet in the office of the Haverhill water works, supplied from Lake Saltonstall.

Microscopical Examination.

No. 9009. Diatomaceæ, *Cyclotella*, 11. Algæ, *Chlorococcus*, 18; *Staurastrum*, 4. Infusoria, *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 4. Total, 38.

No. 9157. Diatomaceæ, *Melosira*, 2; *Navicula*, 2. Cyanophyceæ, *Anabæna*, 10; *Chroöcoccus*, 8; *Clathrocystis*, 4; *Microcystis*, 1. Algæ, *Chlorococcus*, 8; *Cosmarium*, 1; *Hyalotheca*, 10; *Raphidium*, 5; *Scenedesmus*, 1; *Staurastrum*, 24. Miscellaneous, *Zoöglœa*, 208. Total, 284.

Water Supply of Hingham and Hull. — Hingham Water Company.

Chemical Examination of Water from Accord Pond, Hingham.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8613	Mar. 15	Mar. 16	V.slight	V.slight	0.25	2.95	0.95	.0000	.0114	.0100	.0014	0.64	.0040	.0000	0.2

Odor, faintly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 2; *Synedra*, 84; *Tabellaria*, 4. Algæ, *Dictyosphærium*, 11. Infusoria, *Dinobryon*, 6; *Dinobryon cases*, 42. Miscellaneous, *Zoöglœa*, 26. Total, 175.

Water Supply of Holliston. — Holliston Water Company.

Chemical Examination of Water from the Well of the Holliston Water Company.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.												
8437	Jan. 20	Jan. 21	V. slight.	V. slight.	0.02	5.00	.0000	.0008	.26	.0200	.0000	2.1	-
8516	Feb. 16	Feb. 17	None.	None.	0.02	4.20	.0006	.0028	.29	.0180	.0000	2.2	-
8606	Mar. 10	Mar. 11	None.	None.	0.00	4.30	.0000	.0030	.28	.0220	.0000	2.6	-
8739	Apr. 14	Apr. 15	V. slight, milky.	None.	0.02	3.90	.0000	.0034	.24	.0180	.0000	1.6	-
8889	May 12	May 13	Slight, clayey.	V. slight.	0.05	3.25	.0000	.0004	.24	.0120	.0000	2.0	-
8993	June 13	June 13	None.	None.	0.00	3.80	.0006	.0038	.30	.0050	.0000	1.7	-
9121	July 18	July 19	V. slight, milky.	None.	*0.15	4.35	.0000	.0044	.27	.0030	.0001	2.0	-
9243	Aug. 15	Aug. 16	V slight.	V. slight.	0.10	4.55	.0000	.0046	.25	.0050	.0002	2.3	.1500
9390	Sept. 19	Sept. 20	Slight, milky.	V. slight.	0.10	4.35	.0002	.0066	.23	.0070	.0001	1.6	.0250
9536	Oct. 17	Oct. 17	None.	None.	0.06	4.00	.0000	.0094	.26	.0100	.0000	1.8	.0140
9665	Nov. 14	Nov. 15	V. slight.	V. slight.	0.08	4.15	.0000	.0052	.31	.0050	.0001	2.6	.0190
9780	Dec. 12	Dec. 13	None.	None.	0.04	4.10	.0000	.0070	.32	.0050	.0000	2.3	.0070
Av..	....	....	....	....	0.05	4.16	.0001	.0043	.27	.0108	.0000	2.1	.0430

Odor in July, August and September, faintly vegetable; at other times, none. —— The first sample was collected from a faucet supplied from a tap on the main pipe, about half a mile from the pumping station; all others were collected from a faucet at the pumping station while pumping.

* The color of this sample before filtration through filter-paper was 0.25.

HOLLISTON.

Microscopical Examination of Water from the Well of the Holliston Water Company.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	18	12	16	14	14	19	16	20	18	15	13
Number of sample,	8437	8516	8606	8739	8889	8993	9121	9243	9390	9536	9665	9780
PLANTS.												
Diatomaceæ. Synedra,	pr.	0	0	1	pr.	3	1	1	0	0	0	0
Fungi. Crenothrix,	0	pr.	0	0	0	1	4	0	0	0	0	pr.
ANIMALS.												
Infusoria. Dinobryon cases,	0	0	0	0	0	0	0	0	0	0	2	0
Miscellaneous. Zoöglœa,	0	0	0	0	0	0	40	29	0	0	35	2
Total,	pr.	pr.	0	1	pr.	4	45	30	0	0	37	2

Water Supply of Holbrook.

(See *Randolph.*)

Water Supply of Holyoke.

Chemical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8449	Jan. 25	Jan. 26	V.slight.	V.slight.	0.30	5.00	1.10	.0000	.0208	.0164	.0044	.14	.0500	.0000	2.6
8508	Feb. 12	Feb. 13	V.slight.	Cons., earthy.	0.10	4.95	1.35	.0030	.0248	.0202	.0046	.15	.0300	.0002	2.5
8603	Mar. 9	Mar. 11	Slight.	Slight.	0.08	3.90	1.60	.0044	.0282	.0244	.0038	.17	.0200	.0003	2.2
8741	Apr. 15	Apr. 16	Slight.	Slight.	0.15	4.75	1.35	.0026	.0290	.0204	.0086	.14	.0030	.0002	2.5
8891	May 12	May 13	Slight.	Slight.	0.20	6.10	2.90	.0036	.0282	.0220	.0062	.12	.0100	.0000	2.6
8998	June 13	June 15	Slight.	Cons.	0.20	5.20	1.70	.0032	.0244	.0208	.0036	.15	.0050	.0001	2.2
9106	July 12	July 14	Distinct.	Cons., rusty.	0.40	6.15	2.25	.0000	.0314	.0254	.0060	.15	.0030	.0000	3.2
9228	Aug. 10	Aug. 11	Distinct.	Slight.	0.30	6.35	1.75	.0000	.0328	.0292	.0036	.16	.0050	.0001	2.3
9381	Sept. 15	Sept. 16	V.slight.	Slight.	0.60	6.55	2.40	.0072	.0384	.0342	.0042	.12	.0070	.0002	3.4
9520	Oct. 11	Oct 12	Slight.	Slight.	0.65	6.50	2.30	.0076	.0352	.0288	.0064	.12	.0180	.0003	3.2
9679	Nov. 16	Nov. 17	Slight.	Slight.	0.38	5.80	1.70	.0030	.0304	.0284	.0020	.12	.0400	.0002	3.5
9800	Dec. 14	Dec. 15	None.	V.slight.	0.30	5.65	1.95	.0008	.0290	.0256	.0034	.12	.0400	.0001	3.4
Av.	....	....	....	....	0.30	5.57	1.86	.0029	.0294	.0247	.0047	.14	.0192	.0001	2.8

Odor, distinctly vegetable, frequently unpleasant. —— The samples were collected from the reservoir.

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	15	11	16	14	15	14	12	16	13	17	16
Number of sample,	8449	8508	8603	8741	8891	8998	9106	9228	9381	9520	9679	9800
PLANTS.												
Diatomaceæ,	**pr.**	**pr.**	**39**	**42**	**31**	**6**	**2**	**4**	**5**	**0**	**0**	**0**
Cyclotella,	0	0	0	0	24	0	0	0	0	0	0	0
Melosira,	0	0	0	0	6	0	0	0	5	0	0	0
Synedra,	pr.	0	39	42	1	0	2	4	0	0	0	0
Cyanophyceæ,	**0**	**0**	**0**	**10**	**5**	**pr.**	**72**	**27**	**19**	**0**	**0**	**pr.**
Anabæna,	0	0	0	10	3	0	50	19	19	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	6	0	0	0	0
Clathrocystis,	0	0	0	pr.	2	pr.	22	2	0	0	0	pr.
Algæ,	**0**	**0**	**0**	**40**	**25**	**60**	**194**	**140**	**3,973**	**0**	**2**	**1**
Botryococcus,	0	0	0	0	0	1	0	8	1	0	0	0
Chlorococcus,	0	0	0	0	0	9	68	117	3	0	2	1
Closterium,	0	0	0	0	0	0	124	0	0	0	0	0
Protococcus,	0	0	0	0	0	50	0	1	8	0	0	0
Raphidium,	0	0	0	0	25	0	0	10	3,960	0	0	0
Scenedesmus,	0	0	0	0	0	0	2	4	1	0	0	0
Zoöspores,	0	0	0	40	0	0	0	0	0	0	0	pr.
Fungi. Crenothrix,	**2**	**0**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**5**	**1**
ANIMALS.												
Infusoria,	**681**	**2,834**	**45**	**405**	**0**	**0**	**2**	**146**	**21**	**0**	**1**	**0**
Dinobryon,	1	2	8	300	0	0	0	2	0	0	0	0
Dinobryon cases,	0	0	37	92	0	0	0	0	0	0	0	0
Heteronæma,	680	2,832	pr.	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	2	144	21	0	1	0
Uroglena,	0	0	0	13	0	0	0	0	0	0	0	0
Vermes,	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**
Rotatorian ova,	0	0	0	0	0	0	2	0	0	0	0	0
Rotifer,	0	0	0	0	0	0	2	0	0	0	0	0
Crustacea. Daphnia,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**.06**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**6**	**2**	**pr.**	**84**	**0**	**0**	**112**	**176**	**1**	**7**	**98**	**2**
TOTAL,	689	2,836	84	581	62	66	388	493	4,019	7	106	4

HOLYOKE.

Chemical Examination of Water from Whiting Street Storage Reservoir at Various Depths, and also from the Distributing Reservoir and a Faucet in the City.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8794	April 25	April 26	Distinct.	Slight.	0.15	-	-	.0000	.0312	.0246	.0066	-	.0020	.0000	-
8795	April 25	April 26	Slight.	Slight.	0.15	-	-	.0000	.0292	.0222	.0070	-	.0030	.0000	-
8796	April 25	April 26	Slight.	Slight.	0.15	-	-	.0000	.0308	.0256	.0052	-	.0020	.0000	-
8798	April 25	April 26	V. slight.	Slight.	0.15	-	-	.0000	.0254	.0224	.0030	-	.0050	.0000	-
8797	April 25	April 26	Slight.	Slight.	0.15	-	-	.0000	.0300	.0222	.0078	-	.0030	.0000	-
Av..	....	....	....	....	0.15	-	-	.0000	.0293	.0234	.0059	-	.0030	.0000	-

Odor of all samples, vegetable and unpleasant.——The first three samples were collected from the storage reservoir at depths of one, eight and seventeen feet respectively beneath the surface; No. 8798 was collected from the distributing reservoir and No. 8797 from a faucet about half a mile from the latter reservoir.

The samples were collected at a time when the organism *Uroglena* was present in the water of Whiting Street Reservoir. For a description of this organism and the effect of its presence upon the taste and odor of a pond or reservoir, see a paper on *Uroglena* by the biologist of the Board in the Twenty-third Annual Report, pages 645-657.

Microscopical Examination of Water from Whiting Street Storage Reservoir at Various Depths, and also from the Distributing Reservoir and a Faucet in the City.

[Number of organisms per cubic centimeter.]

	1892. April.	1892. April.	1892. April.	1892. April.	1892. April.
Day of examination,	26	26	26	26	26
Number of sample,	8794	8795	8796	8798	8797
PLANTS.					
Diatomaceæ,	**5**	**15**	**4**	**21**	**10**
Diatoma,	0	0	0	2	0
Epithemia,	0	0	0	0	2
Fragilaria,	0	0	0	2	0
Meridion,	0	0	0	1	0
Navicula,	0	0	0	1	0
Synedra,	5	15	4	15	8
Cyanophyceæ. Anabæna,	**2**	**3**	**1**	**1**	**1**
Algæ,	**5**	**1**	**0**	**4**	**4**
Cosmarium,	1	0	0	0	0
Raphidium,	4	0	0	4	4
Zoöspores,	0	1	0	0	0

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir at Various Depths, and also from the Distributing Reservoir and a Faucet in the City — Concluded.

[Number of organisms per cubic centimeter.]

	1892.				
	April.	April.	April.	April.	April.
ANIMALS.					
Infusoria,	**335**	**282**	**144**	**236**	**48**
Dinobryon,	228	132	0	85	0
Dinobryon cases,	0	0	144	34	7
Monas,	5	0	0	0	0
Peridinium,	6	2	0	1	1
Uroglena,	96	148	0	116	40
Vermes,	**0**	**3**	**0**	**1**	**1**
Anguillula,	0	0	0	0	1
Asplanchna,	0	2	0	1	0
Polyarthra,	0	1	0	0	0
Crustacea. Daphnia,	**.02**	**0**	**.04**	**0**	**0**
Totals,	347	304	149	263	64

Chemical Examination of Water from the Underdrains beneath the Whiting Street Storage Reservoir.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1892.														
8427	Jan. 18	Jan. 19	V. slight.	V. slight.	0.10	5.75	1.50	.0034	.0214	.0176	.0038	.13	.0450	.0001	2.6

Odor, vegetable. —— The sample was collected from a pipe leading from the underdrains laid beneath the reservoir to obtain filtered water.

Microscopical Examination.

Diatomaceæ, *Synedra*, 1; *Tabellaria*, 1. Fungi, *Crenothrix*, 34. Infusoria, *Monas*, 89. Crustacea, *Cyclops*, .01. Miscellaneous, *Zoöglœa*, 24. Total, 150.

HOLYOKE.

Chemical Examination of Water from Wright Pond, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8890	May 12	May 13	Distinct.	Slight.	0.02	5.10	1.15	.0008	.0196	.0154	.0042	.17	.0020	.0000	3.1

Odor, faintly vegetable, becoming stronger and unpleasant on heating.——The sample was collected from Wright Pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 340; *Cyclotella*, 204; *Diatoma*, 6; *Fragilaria*, 48; *Meridion*, 248; *Stephanodiscus*, 3; *Synedra*, 192; *Tabellaria*, 112. Cyanophyceæ, *Anabæna*, 5. Algæ, *Chlorococcus*, 16; *Hyalotheca*, 17; *Scenedesmus*, 1. Infusoria, *Dinobryon cases*, 4; *Peridinium*, 3; *Trachelomonas*, 2. Crustacea, *Bosmina*, .02. Miscellaneous, *Zoöglœa*, 4. Total, 1,205.

Water Supply of Hopedale.

(See *Milford.*)

Water Supply of Hull.

(See *Hingham.*)

Water Supply of Hyde Park and Milton.—Hyde Park Water Company.

During a portion of the summer of 1892 the Hyde Park Water Company used as an additional source of supply the water of a large well formerly used for supplying water to a starch factory. This well is situated on the right bank of the Neponset River, about sixty-five feet from it and a few hundred feet down stream from a system of tubular wells from which the whole of the water company's supply had hitherto been drawn. The tables which follow contain analyses of water taken directly from this well and also from faucets in Hyde Park and Milton, which were supplied wholly or in part from this source. These analyses indicate that the water of the well was to a large extent imperfectly filtered river water. The temperature of the water from this well, although lower than that of the river water, was much higher than that of water drawn from the tubular wells, a further indication that a portion of the supply

came somewhat directly from the river. Further information with regard to the water supply of Hyde Park and Milton may be found on pages 14 and 35 of this volume.

Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company.

[Parts per 100,000]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9088	July 12	July 13	None.	None.	0.0	6.80	.0006	.0032	.92	.0500	.0002	3.1	-
9154	July 27	July 27	None.	None.	0.0	7.60	.0002	.0038	1.06	.0500	.0005	2.8	-

Odor, none.—— The samples were collected from a faucet at the pumping station while pumping from the tubular wells.

Microscopical Examination.

No. 9088. No organisms. No. 9154. Fungi, *Crenothrix*, 2.

Chemical Examination of Water from the Well at the Starch Factory used as a Source of Additional Water Supply by the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9152	July 27	July 27	Slight.	Cons.	0.25	9.70	.0444	.0086	1.53	.0400	.0005	3.6	-
9204	Aug. 4	Aug. 6	Distinct, milky.	Cons., white.	0.20	8.95	.0440	.0070	1.70	.0250	.0000	3.6	.0495

Odor, disagreeable.—— The samples were collected from the well at the starch factory.

Microscopical Examination.

No. 9152. Fungi, *Crenothrix*, 16. Miscellaneous, *Zoöglœa*, 168. Total, 184.

No. 9204. Diatomaceæ, *Tabellaria*, 1. Fungi, *Crenothrix*, 156. Miscellaneous, *Zoöglœa*, 120. Total, 277.

HYDE PARK.

Chemical Examination of Water from the covered Tank of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9089	July 12	July 13	V. slight.	V. slight.	0.00	11.45	.0082	.0072	.94	.0500	.0050	2.7	-
9155	July 27	July 27	V. slight.	Slight, white.	0.02	8.85	.0226	.0070	1.15	.0600	.0025	3.2	-

Odor of the first sample, faintly vegetable and unpleasant; of the last, none. —— The samples were collected from the tank near the surface.

Microscopical Examination.

No. 9089. Miscellaneous, *Zoöglœa*, 112.
No. 9155. Fungi, *Crenothrix*, 10; Miscellaneous, *Zoöglœa*, 660. Total, 670.

Chemical Examination of Water from a Faucet in Hyde Park supplied from the Works of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9382	Sept. 16	Sept. 16	V. slight.	Cons., dark.	0.02	8.70	.0010	.0026	1.26	.0380	.0001	3.4	.0140
9429	Sept. 23	Sept. 23	Distinct.	Cons., rusty.	0.02	10.40	.0000	.0084	1.33	.0500	.0002	3.8	.0240
9477	Sept. 30	Oct. 1	Slight.	Slight, brown.	0.05	9.45	.0008	.0052	1.30	.0600	.0004	4.4	.0360
9499	Oct. 7	Oct. 7	Distinct.	Cons., rusty.	0.05	9.00	.0004	.0066	1.46	.0650	.0003	3.9	.0470
Av.	....	....	....	....	0.03	9.57	.0005	.0057	1.34	.0532	.0002	3.9	.0302

Odor, very faint or none. —— The samples were collected from a faucet in a building at the corner of Hyde Park Avenue and River Street.

HYDE PARK.

Microscopical Examination of Water from a Faucet in Hyde Park supplied from the Works of the Hyde Park Water Company.

[Number of organisms per cubic centimeter.]

	1892.			
	Sept.	Sept.	Oct.	Oct.
Day of examination,	16	28	4	8
Number of sample,	9382	9429	9477	9499
PLANTS.				
Fungi. Crenothrix,	66	192	164	292
ANIMALS.				
Infusoria,	pr.	2	0	0
Monas,	0	2	0	0
Trachelomonas,	pr.	0	0	0
Crustacea. Daphnia,	0	.02	0	0
Miscellaneous. Zoöglœa,	90	0	128	0
TOTAL,	156	194	292	292

Chemical Examination of Water from Faucets in Milton supplied from the Works of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation.	Ammonia: Free.	Ammonia: Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9099	July 13	July 13	Distinct, milky.	Cons., rusty.	*0.50	7.85	.0032	.0024	0.92	.0300	-	3.5	.5833
9172	July 30	July 30	Slight.	Heavy, rusty.	0.00	8.85	.0382	.0066	1.23	.0020	.0005	3.6	-
9388	Sept. 19	Sept. 19	Distinct, rusty.	Cons., rusty.	0.02	8.50	.0012	.0006	1.24	.0500	.0000	3.2	.1050
9432	Sept. 23	Sept 24	V. slight.	Slight, rusty.	0.02	8.70	.0000	.0048	1.39	.0600	.0000	3.9	.0150
9476	Sept. 29	Sept. 30	None.	None.	0.03	8.50	.0000	.0034	1.18	.0900	.0000	3.8	.0070
9500	Oct. 6	Oct. 7	None.	None.	0.02	8.40	.0000	.0008	1.24	.0600	.0000	3.5	.0040
9532	Oct. 13	Oct. 14	None.	None.	0.01	8.75	.0000	.0016	1.34	.0600	.0000	4.3	.0050
Av.	....	....	....	....	0.09	8.51	.0061	.0029	1.22	.0503	.1144	3.7	.1199

Odor of No. 9172, faintly vegetable; of No. 9388, faintly disagreeable; of all others, none.

* This color was determined after the sample had been standing three hours in the laboratory; the color increased on standing.

HYDE PARK.

Microscopical Examination of Water from Faucets in Milton supplied from the Works of the Hyde Park Water Company.

[Number of organisms per cubic centimeter.]

	1892. July.	1892. July.	1892. Sept.	1892. Sept.	1892. Sept.	1892. Oct.	1892. Oct.
Day of examination,	13	30	20	27	30	8	15
Number of sample,	9099	9172	9388	9432	9476	9500	9532
PLANTS.							
Fungi. Crenothrix,	0	0	180	26	0	0	0
ANIMALS.							
Infusoria,	0	0	0	4	0	0	0
Miscellaneous.							
Zoöglœa,	0	0	356	*	0	0	0
Iron rust,	740	552	0	0	0	0	0
TOTAL,	740	552	536	30	0	0	0

* Very abundant.

Chemical Examination of Water from the Neponset River, at Hyde Park.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9153	July 27	July 27	Slight.	Cons.	0.9	13.30	2.85	.0260	.0324	.0286	.0038	2.31	.0090	.0012	4.4

Odor, very disagreeable and musty.—The sample was collected from the river opposite the pumping station of the Hyde Park Water Company.

Microscopical Examination.

Diatomaceæ, *Grammatophora*, 1; *Synedra*, 5. Cyanophyceæ, *Chroöcoccus*, 21. Algæ, *Botryococcus*, 2; *Chlorococcus*, 364; *Polyedrium*, 1; *Protococcus*, 2; *Raphidium*, 8; *Scenedesmus*, 28; *Sorastrum*, 9; *Staurogenia*, 2; Fungi, *Crenothrix*, 512; *Molds*, 1. Infusoria, *Euglena*, 2; *Trachelomonas*, 6. Miscellaneous, *Zoöglœa*, 236. Total, 1,200.

Ipswich.

The advice of the State Board of Health to the town of Ipswich, with reference to the propriety of taking certain springs in Ipswich as a source of water supply, may be found on page 15 of this report. An analysis of water from one of these springs is given below.

Chemical Examination of Water from a Spring in Ipswich.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9166	July 27	July 28	V. slight.	V. slight.	0.0	11.60	.0004	.0020	1.53	.1300	.0000	3.6	–

Odor, faintly vegetable. —— The sample was collected from a spring in a wet meadow on the farm of Augustine Stone, about one mile south of Ipswich.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 3; *Navicula*, 1; *Synedra*, 3; *Tabellaria*, 5. Total, 12.

Chemical Examination of Water from Miles River at Ipswich.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9165	July 27	July 28	Slight.	Slight.	0.65	7.50	1.60	.0010	.0204	.0180	.0024	1.10	.0100	.0004	2.9

Odor, strongly vegetable. —— The sample was collected from the river at the second road crossing above the Ipswich River.

Microscopical Examination.

Fungi, *Crenothrix*, 13.

KINGSTON.

Water Supply of Kingston.

The filter-gallery, which was rebuilt and extended in 1891, failed to furnish in connection with the well a sufficient amount of water for the needs of the town, and for a short time in the summer of 1892 water was pumped from Stetson's Pond to supply the deficiency.

The advice of the State Board of Health to the town of Kingston with reference to the quality of the existing water supply, and as to the propriety of taking the water of Stetson's Pond as an additional source of supply, may be found on page 16 of this report.

Chemical Examination of Water from the Filter-Gallery, Kingston.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.												
9207	Aug. 6	Aug. 8	Slight.	Slight.	0.02	4.75	.0000	.0008	.81	.0850	.0001	1.7	.0270

Odor, none.——The sample was collected from the filter-gallery at its lower end, where the water enters a pipe leading to the well.

Microscopical Examination.

Fungi, *Crenothrix*, 414. Miscellaneous, *Zoöglœa*, 62. Total, 476.

Chemical Examination of Water from Stetson's Pond, Kingston.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
9206	Aug. 6	Aug. 8	Slight.	Slight.	0.08	3.55	1.05	.0026	.0114	.0066	.0048	0.73	.0000	.0000	0.3

Odor, distinctly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 16; *Diatoma*, 1; *Fragilaria*, 3; *Melosira*, 2; *Synedra*, 54. Cyanophyceæ, *Anabæna*, 400; *Anabæna Spores*, 17. Algæ, *Chlorococcus*, 54; *Nephrocytium*, 4; *Pandorina*, 50; *Sorastrum*, 1. Miscellaneous, *Zoöglœa*, 28. Total, 630.

Water Supply of Lawrence.*

In the autumn of 1892 the city of Lawrence began the construction of a filter-bed on the bank of the river, adjacent to the old filter-gallery, which will serve as the main drain. This filter-bed was not completed at the end of the year, so that during the whole of 1892 the water supply has been taken from the river, as in previous years. The advice of the State Board of Health to the water board of Lawrence relative to the filtration of the Merrimack River water may be found on pages 16–19 of this volume.

Chemical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8522	Feb. 17	Feb. 18	Slight.	Slight.	0.22	4.60	1.50	.0038	.0172	.0146	.0026	.21	.0120	.0001	1.4
8628	Mar. 16	Mar. 17	Slight.	Slight.	0.50	3.75	1.10	.0000	.0166	.0144	.0022	.16	.0120	.0001	1.3
8836	May 2	May 3	Slight.	Slight.	0.25	3.50	1.30	.0044	.0156	.0120	.0036	.15	.0070	.0002	1.1
8912	May 18	May 19	Slight.	Cons., earthy.	0.55	3.90	1.40	.0026	.0176	.0158	.0018	.15	.0180	.0000	1.3
9004	June 15	June 16	Slight.	Cons.	0.40	4.65	1.40	.0056	.0186	.0152	.0034	.16	.0100	.0002	1.1
9131	July 20	July 20	V. slight.	Slight.	0.40	4.05	1.30	.0068	.0168	.0134	.0034	.20	.0050	.0002	1.6
9264	Aug. 17	Aug. 18	Distinct.	Slight.	0.35	4.00	1.70	.0052	.0192	.0162	.0030	.20	.0050	.0002	1.1
9416	Sept. 21	Sept. 23	Slight.	Slight, white.	0.70	4.05	1.70	.0056	.0200	.0168	.0032	.16	.0100	.0001	1.3
9545	Oct. 19	Oct. 20	V. slight.	V. slight.	0.32	4.50	1.25	.0064	.0186	.0150	.0036	.26	.0070	.0002	1.7
9680	Nov. 16	Nov. 17	Distinct.	Cons.	0.60	4.25	1.65	.0026	.0186	.0162	.0024	.19	.0150	.0001	2.1
9794	Dec. 14	Dec. 15	Slight, clayey.	Cons., earthy.	0.48	4.05	1.85	.0030	.0204	.0182	.0022	.19	.0150	.0002	1.3
Av.	....	....	....	....	0.43	4.12	1.47	.0042	.0181	.0152	.0029	.18	.0105	.0001	1.4

Odor, generally musty and vegetable.—— The samples were collected from the middle of the river, opposite the intake of the Lawrence water works. For a record of the amount of water flowing in the river on dates when samples of water were collected, see page 153.

* In addition to the analyses given here, other analyses of the Lawrence water supply, made at the Lawrence experiment station, will be found in a subsequent portion of this report.

LAWRENCE.

Microscopical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1892.										
	Feb.	Mar.	May.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	19	4	19	16	21	18	23	20	17	15
Number of sample,	8522	8628	8836	8912	9004	9131	9264	9416	9545	9680	9794
PLANTS.											
Diatomaceæ,	**6**	**4**	**96**	**111**	**201**	**82**	**59**	**19**	**30**	**20**	**9**
Asterionella,	3	1	37	34	2	0	1	8	8	3	0
Diatoma,	0	0	pr.	0	0	4	2	0	pr.	1	0
Fragilaria,	0	0	0	1	0	0	21	0	7	0	2
Melosira,	0	0	8	4	14	2	0	0	0	5	0
Navicula,	0	0	3	pr.	2	3	2	2	1	0	0
Synedra,	3	3	58	68	178	52	30	9	9	4	2
Tabellaria,	0	0	0	4	5	21	3	0	5	7	5
Cyanophyceæ. Chroöcoccus,	**8**	**0**	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**
Algæ,	**0**	**0**	**1**	**0**	**6**	**24**	**6**	**0**	**0**	**5**	**0**
Chlorococcus,	0	0	0	0	6	19	4	0	0	0	0
Raphidium,	0	0	1	0	0	4	2	0	0	0	0
Zoöspores,	0	0	0	0	0	1	0	0	0	5	0
Fungi. Crenothrix,	**0**	**1**	**7**	**42**	**15**	**46**	**7**	**60**	**28**	**3**	**0**
ANIMALS.											
Infusoria,	**2**	**0**	**5**	**0**	**25**	**8**	**2**	**9**	**0**	**1**	**2**
Dinobryon,	2	0	0	0	0	0	0	8	0	0	0
Dinobryon cases,	0	0	5	0	24	0	0	0	0	0	1
Monas,	0	0	0	0	1	0	0	1	0	1	0
Peridinium,	0	0	0	0	0	7	2	0	0	0	0
Trachelomonas,	0	0	0	0	0	1	0	0	0	0	1
Miscellaneous. Zoöglœa,	**128**	**74**	**94**	**196**	**456**	**480**	**248**	**180**	**108**	**212**	**220**
TOTAL,	144	79	203	349	703	640	330	268	166	241	231

LAWRENCE.

Chemical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8432	Jan. 19	Jan. 20	Distinct.	Cons., earthy.	0.58	3.30	1.60	.0004	.0130	.0098	.0032	.13	.0200	.0000	1.1
8524	Feb. 17	Feb. 18	Slight.	Cons., earthy.	0.22	4.25	2.00	.0028	.0178	.0138	.0040	.21	.0180	.0001	1.4
8629	Mar. 16	Mar. 17	Slight.	Cons.	0.45	3.90	1.40	.0000	.0166	.0138	.0028	.17	.0180	.0001	1.1
8771	Apr. 20	Apr. 21	Slight.	Slight.	0.23	4.70	1.85	.0010	.0178	.0156	.0022	.19	.0120	.0000	1.6
8913	May 18	May 19	Slight.	Cons., earthy.	0.53	4.20	1.80	.0032	.0198	.0132	.0066	.15	.0140	.0000	1.1
9005	June 15	June 16	Slight.	Cons.	0.35	4.05	1.65	.0054	.0176	.0142	.0034	.16	.0090	.0002	0.9
9132	July 20	July 20	Slight.	Cons., green.	0.30	4.30	1.55	.0076	.0136	.0110	.0026	.20	.0050	.0002	1.8
9266	Aug. 17	Aug. 18	Distinct.	Cons.	0.32	3.70	1.65	.0058	.0222	.0178	.0044	.20	.0120	.0001	1.3
9417	Sept. 21	Sept. 23	V. slight.	Slight, white.	0.60	4.25	1.75	.0052	.0202	.0186	.0016	.19	.0100	.0002	1.3
9547	Oct. 19	Oct. 20	Distinct.	Cons., earthy.	0.38	4.50	1.20	.0054	.0182	.0146	.0036	.27	.0090	.0002	1.5
9682	Nov. 16	Nov. 17	Distinct.	Cons.	0.65	4.55	1.95	.0024	.0190	.0160	.0030	.20	.0200	.0000	1.9
9796	Dec. 14	Dec. 15	Slight, clayey.	Slight, earthy.	0.50	4.10	1.50	.0034	.0222	.0164	.0058	.21	.0180	.0000	1.3
Av.	....	....	....	....	0.43	4.15	1.66	.0035	.0182	.0146	.0036	.19	.0137	.0001	1.4

Odor, musty and vegetable, becoming somewhat stronger on heating. —— The samples were collected from a faucet in the check-valve just beyond the pump, and represent a mixture of water from the river and the filter-gallery, though but a small part of the water comes from the latter source.

Microscopical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	19	19	21	19	16	21	18	23	20	17	15
Number of sample,	8432	8524	8629	8771	8913	9005	9132	9266	9417	9547	9682	9796
PLANTS.												
Diatomaceæ,	**18**	**8**	**16**	**63**	**155**	**172**	**84**	**42**	**406**	**34**	**66**	**17**
Asterionella,	3	1	0	2	3	4	0	0	0	2	0	3
Cymbella,	0	0	0	0	0	0	7	0	0	pr.	0	0
Diatoma,	0	0	0	0	1	pr.	0	0	0	1	5	0
Epithemia,	0	0	0	4	pr.	0	1	0	0	pr.	0	0
Fragilaria,	0	0	0	0	1	3	0	2	0	0	13	0
Melosira,	2	0	pr.	19	4	8	4	10	0	4	31	10
Navicula,	10	0	1	pr.	3	3	8	3	2	1	7	0
Synedra,	3	7	15	38	142	152	56	27	404	26	10	2
Tabellaria,	0	0	0	0	1	2	8	0	0	0	0	2

LAWRENCE.

Microscopical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	0	pr.	0	0	0	pr.	22	24	1	pr.	0	0
Chlorococcus,	0	pr.	0	0	0	pr.	18	23	0	pr.	0	0
Cosmarium,	0	0	0	0	0	0	4	1	1	0	0	0
Fungi. Crenothrix,	23	41	16	0	44	14	30	44	108	9	2	0
ANIMALS.												
Infusoria,	0	2	4	3	3	4	1	0	5	0	2	0
Dinobryon,	0	2	1	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	2	3	4	0	0	0	0	2	0
Monas,	0	0	3	0	0	0	1	0	0	0	0	0
Peridinium,	0	0	0	1	0	0	0	0	5	0	0	0
Miscellaneous. Zoöglœa,	154	126	100	128	180	386	532	696	164	102	232	0
TOTAL,	195	177	136	194	382	576	669	806	684	145	302	17

Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended		Nitrates.	Nitrites.	
	1892.														
8433	Jan. 19	Jan. 20	Slight.	Slight.	0.55	3.75	1.75	.0012	.0118	.0102	.0016	.15	.0200	.0000	1.1
8523	Feb. 17	Feb. 18	V. slight.	V. slight.	0.23	4.30	1.95	.0028	.0140	.0122	.0018	.20	.0100	.0001	1.4
8630	Mar. 16	Mar. 17	Slight.	Slight.	0.40	4.05	1.10	.0030	.0150	.0116	.0034	.20	.0180	.0001	1.3
8772	Apr. 20	Apr. 21	V. slight.	Slight.	0.20	3.95	1.65	.0014	.0132	.0104	.0028	.16	.0130	.0000	1.3
8914	May 18	May 19	V. slight.	Cons.	0.40	3.60	1.55	.0038	.0154	.0136	.0018	.17	.0180	.0000	1.1
9006	June 15	June 16	Slight.	V. slight.	0.35	3.60	1.50	.0020	.0148	.0118	.0030	.16	.0120	.0001	0.8
9133	July 20	July 20	V. slight.	V. slight.	0.40	3.70	1.50	.0092	.0142	.0122	.0020	.17	.0030	.0001	1.5
9265	Aug. 17	Aug. 18	V. slight.	V. slight.	0.18	3.80	1.70	.0084	.0148	.0130	.0018	.22	.0150	.0003	1.3
9418	Sept. 21	Sept. 23	Slight.	Slight.	0.45	4.30	1.95	.0004	.0244	.0216	.0028	.19	.0180	.0002	1.3
9546	Oct. 19	Oct. 20	V. slight.	Slight.	0.36	4.40	1.35	.0060	.0180	.0146	.0034	.25	.0090	.0001	1.7
9681	Nov. 16	Nov. 17	V. slight.	V. slight.	0.35	4.10	1.50	.0034	.0178	.0140	.0038	.20	.0120	.0001	1.8
9795	Dec. 14	Dec. 15	Slight, clayey.	V. slight.	0.50	4.05	1.55	.0032	.0162	.0132	.0030	.19	.0180	.0000	1.6
Av.	....	....	....	....	0.36	3.97	1.59	.0037	.0158	.0132	.0026	.19	.0138	.0001	1.3

Odor, faintly vegetable and somewhat mouldy. —— The samples were collected from a faucet in the gate-house, and represent water flowing out of the reservoir.

LAWRENCE.

Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	19	19	21	21	16	21	18	23	20	17	15
Number of sample,	8433	8523	8630	8772	8914	9006	9133	9265	9418	9546	9681	9795
PLANTS.												
Diatomaceæ,	8	22	22	68	46	9	6	23	2	8	23	3
Asterionella,	0	6	0	8	2	1	0	3	0	4	2	2
Fragilaria,	0	0	18	0	0	0	6	15	0	0	0	0
Melosira,	0	1	0	0	3	0	0	2	0	0	0	0
Navicula,	3	2	1	pr.	1	0	0	0	0	0	4	0
Synedra,	5	13	3	60	38	7	0	3	1	4	13	0
Tabellaria,	0	0	0	0	2	1	0	0	1	0	4	1
Algæ,	0	0	0	0	0	0	68	37	10	1	1	0
Botrycoccus,	0	0	0	0	0	0	0	25	2	0	0	0
Chlorococcus,	0	0	0	0	0	0	68	12	8	1	1	0
Fungi. Crenothrix,	3	1	2	0	20	2	0	10	36	3	6	0
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	0	0	0	0	4	0	0	0
Infusoria. Dinobryon cases,	0	pr.	pr.	1	pr.	2	0	0	0	0	1	2
Miscellaneous. Zoöglœa,	7	36	42	7	184	2	0	82	0	100	136	68
TOTAL,	18	59	66	76	250	15	74	152	52	112	167	73

Volume of Water Flowing in the Merrimack River at Lawrence on the Dates when Samples of Water were collected for Analysis.

DATE.	Volume Flowing in the Merrimack River in Cubic Feet per Second.		DATE.	Volume Flowing in the Merrimack River in Cubic Feet per Second.	
	Rate of Flow during Eleven Hours of the Day.	Rate of Flow during Twenty-four Hours of the Day.		Rate of Flow during Eleven Hours of the Day.	Rate of Flow during Twenty-four Hours of the Day.
1892.			**1892** — Con.		
Jan. 19,	14,470	13,560	July 20,	3,590	2,690
Feb. 17,	7,500	6,700	Aug 17,	5,400	4,560
Mar. 16,	8,640	7,780	Sept. 21,	4,790	3,880
May 2,	6,990	6,200	Oct. 19,	3,460	2,550
May 18,	12,280	11,400	Nov. 16,	5,600	4,790
June 15,	5,050	4,220	Dec. 14,	5,810	4,990

LEICESTER.

WATER SUPPLY OF THE LEICESTER WATER SUPPLY DISTRICT, LEICESTER.

Chemical Examination of Water from the Wells of the Leicester Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8790	Apr. 21	Apr. 23	Slight, clayey.	V. slight.	0.02	5.35	.0000	.0000	.20	.0900	.0000	2.1	–
8894	May 14	May 14	V. slight.	Slight.	0.08	4.55	.0000	.0040	.20	.1100	.0003	2.0	–
8989	June 10	June 13	None.	None.	0.15	4.55	.0006	.0020	.26	.0500	.0000	1.9	–
9120	July 18	July 19	None.	None.	0.00	4.70	.0004	.0022	.23	.1500	.0001	1.9	–
9263	Aug. 17	Aug. 18	Slight, milky.	V. slight.	0.20	6.05	.0002	.0086	.18	.0300	.0004	3.4	.0650
9421	Sept. 21	Sept. 23	Slight, milky.	Slight.	0.20	7.10	.0018	.0060	.44	.0320	.0005	2.6	.0390
9554	Oct. 20	Oct. 22	None.	None.	0.02	4.80	.0010	.0008	.19	.0700	.0000	1.9	.0050
9684	Nov. 16	Nov. 17	V. slight	V. slight.	0.15	7.40	.0000	.0064	.16	.0750	.0000	3.6	.0090
9799	Dec. 14	Dec. 15	None.	None.	0.10	5.65	.0000	.0066	.20	.0550	.0000	2.3	.0035
Av.	....	....	....	....	0.10	5.57	.0004	.0041	.23	.0736	.0001	2.4	.0243

Odor of Nos. 8894 and 9263, strongly musty, the former becoming disagreeable on heating; of all other samples, very faint or none. —— Nos. 8894 and 9421 were collected from a faucet at the distributing tank; the remaining samples were collected from faucets in the village, generally about four thousand feet from the tank. One sample, No. 9263, was collected from a faucet supplied from a tap at the dead end of a six-inch main.

Microscopical Examination of Water from the Wells of the Leicester Water Supply District.

[Number of organisms per cubic centimeter.]

	1892. Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	17	14	19	18	23	24	17	16
Number of sample,	8790	8894	8989	9120	9263	9421	9554	9684	9799
PLANTS.									
Diatomaceæ,	**1**	**10**	**9**	**0**	**0**	**9**	**0**	**14**	**82**
Asterionella,	0	4	0	0	0	0	0	14	82
Synedra,	1	6	9	0	0	1	0	0	pr.
Tabellaria,	0	0	0	0	0	8	0	0	0
Algæ. Scenedesmus,	**0**	**4**	**pr.**	**0**	**0**	**1**	**0**	**pr.**	**0**
ANIMALS.									
Infusoria,	**0**	**pr.**	**0**	**0**	**0**	**31**	**pr.**	**0**	**pr.**
Dinobryon cases,	0	0	0	0	0	19	0	0	0
Peridinium,	0	pr.	0	0	0	12	pr.	0	pr.
Miscellaneous. Zoöglœa,	**0**	**33**	**0**	**0**	**0**	**18**	**3**	**19**	**2**
TOTAL,	1	47	9	0	0	59	3	33	84

Water Supply of Lexington. — Lexington Water Company.

In 1892 these works were still further enlarged by the construction of a covered gallery and a well, nearer the village than the original works. The gallery is located 1,540 feet from the nearest of the original wells. It is seventy feet long, six feet wide and six feet high, and is constructed of wood. In its bottom, which is eleven feet beneath the surface of the ground, there are two half-inch tubular wells and a drain-pipe well ten inches in diameter. The new well is lined with stone, and is one hundred feet further from the original wells than the gallery, with which it is connected by a four-inch drain-pipe laid nine feet beneath the surface of the ground. The material found in the vicinity of the gallery and well was not very porous, and the additional water supply obtained not large. The piping from the gallery to the present works is so arranged that the water can be turned into one of the original wells or taken directly into the suction pipe.

Chemical Examination of Water from the Works of the Lexington Water Company.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.												
9489	Oct. 3	Oct. 4	None.	None.	0.00	14.25	.0000	.0008	1.44	.1200	.0023	7.0	.0050
9490	Oct. 3	Oct. 4	None.	None.	0.04	10.70	.0344	.0022	0.86	.7000	.0021	6.7	.0025

Odor, none. —— The first sample was collected from one of the tubular wells in the bottom of the covered gallery; the second sample from the drain pipe which conveys water from the new well into the gallery.

Microscopical Examination.

No organisms.

Water Supply of Lincoln.

(See *Concord.*)

LOWELL.

Water Supply of Lowell.

In the latter part of 1891 the city of Lowell began to make investigations with a view to obtaining a new supply of water from driven wells, and these investigations were continued during a part of the year 1892. In addition to the monthly analyses of samples of water taken from the Merrimack River, which is the present source of supply, many chemical and bacterial examinations were made of samples of water from these driven wells, and the results may be found in tables which follow. The wells are designated as Barker, Pierce and Andrews wells, in accordance with the names of the men who drove them. The Barker and Pierce wells were all driven in the latter part of 1891, on the north bank of the Merrimack River, above the upper end of the present filter-gallery and between the Pawtucket Boulevard and the river. The examinations covered a length along the river of about 1.5 miles. The Andrews wells were all driven after July 16, 1892, and three localities were tested, as follows: first, the land west of the present filter-gallery, between the Pawtucket Boulevard and the Merrimack River; second, land near the junction of the river and Beaver Brook, a tributary which enters the river from the north opposite the city; third, land in the southerly part of the city on both sides of River Meadow Brook, owned by the city of Lowell and used as a city farm. No analyses were made of water from the second location, as the tests showed that very little ground water could be obtained at this place. The city adopted the third location as the most favorable place for obtaining a part or the whole of the ground water required for the supply of the city. A description of these wells, with records of water pumped from them and such other data as may have a bearing upon the analyses, are given in connection with the tables. One noteworthy feature is the change in the character of the water pumped from the ground, when several wells just east of the Old Ferry Road on the north bank of the Merrimack River were connected together and pumped for a long time with a steam pump. In this instance there was a very decided deterioration in the quality of the water as the test progressed, the amount of free ammonia and iron increasing very rapidly (see page 160). Subsequent pumping tests from other wells near the Merrimack River, and near River Meadow Brook (page 162) gave different

results, as they showed very little change in the character of the water during the tests.

On May 4, 1892, the Lowell water board asked the advice of the State Board of Health with regard to obtaining a water supply for Lowell by means of a system of driven wells. The attention of the Board was called to the localities on the northerly bank of the Merrimack River, near the Pawtucket Boulevard and near Beaver Brook. The reply to the Lowell water board, which may be found on pages 20–29 of this volume, was made on September 3, when the pumping test from driven wells just east of the Old Ferry Road was nearly completed. In connection with the investigations of the State Board of Health relative to an additional water supply for Lowell, analyses were made of several surface water sources near the city, in Chelmsford, Tyngsborough and Westford, and will be found tabulated under the names of these towns.

Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8434	Jan. 19	Jan. 20	Distinct.	Cons., earthy.	0.55	3.30	1.50	.0000	.0102	.0086	.0016	.08	.0100	.0000	0.6
8515	Feb. 16	Feb. 17	Slight, clayey.	V. slight.	0.20	3.50	1.15	.0034	.0128	.0120	.0008	.20	.0090	.0000	1.3
8616	Mar. 15	Mar. 16	V. slight.	Slight.	0.40	3.30	1.35	.0018	.0184	.0124	.0060	.13	.0100	.0000	0.6
8791	Apr. 22	Apr. 23	Slight.	Slight.	0.25	3.85	1.40	.0014	.0116	.0100	.0016	.14	.0050	.0000	1.0
8902	May 17	May 18	V. slight.	Cons.	0.50	3.30	1.30	.0002	.0164	.0142	.0022	.10	.0100	.0000	1.1
8999	June 14	June 15	Distinct, green.	Cons., green.	0.35	3.50	1.40	.0010	.0152	.0110	.0042	.12	.0090	.0001	0.9
9126	July 19	July 20	V. slight.	Slight.	0.28	3.60	1.10	.0026	.0168	.0132	.0036	.14	.0050	.0002	1.7
9315	Aug. 27	Aug. 29	Slight.	Cons., rusty.	0.28	4.15	1.35	.0040	.0140	.0124	.0016	.16	.0100	.0000	2.1
9399	Sept. 20	Sept. 20	Slight.	Slight.	0.65	3.55	1.60	.0030	.0134	.0096	.0038	.09	.0070	.0010	1.0
9537	Oct. 17	Oct. 18	V. slight.	Slight.	0.35	3.75	1.35	.0028	.0100	.0068	.0032	.19	.0070	.0000	1.6
9676	Nov. 15	Nov. 16	Slight.	Slight.	0.45	3.95	1.45	.0034	.0138	.0108	.0030	.20	.0200	.0000	2.3
9787	Dec. 13	Dec. 14	Slight.	Slight.	0.40	3.60	1.35	.0022	.0168	.0144	.0024	.14	.0090	.0000	1.5
Av.	....	....	....	....	0.39	3.61	1.36	.0021	.0141	.0113	.0028	.14	.0092	.0001	1.3

Odor, vegetable; frequently also mouldy.——The samples were collected from the river, one foot beneath the surface.

LOWELL.

Microscopical Examination of Water from the Merrimack River above Lowell opposite the Intake of the Lowell Water Works.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	18	17	23	19	15	20	31	21	18	16	14
Number of sample,	8434	8515	8616	8791	8902	8999	9126	9315	9399	9537	9676	9787
PLANTS.												
Diatomaceæ,	**10**	**11**	**39**	**39**	**110**	**261**	**32**	**146**	**6**	**66**	**18**	**25**
Asterionella,	0	0	0	14	30	34	2	0	0	2	0	0
Diatoma,	0	0	0	pr	pr.	0	3	2	0	1	1	0
Fragilaria,	0	1	0	1	0	0	8	26	2	1	0	0
Melosira,	5	0	5	0	6	4	2	2	0	0	10	23
Navicula,	3	1	pr.	0	2	3	2	2	1	pr.	0	0
Synedra,	2	9	32	24	72	200	13	114	3	62	1	2
Tabellaria,	pr.	0	2	0	0	20	2	pr.	0	0	6	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**15**	**35**	**60**	**0**	**9**	**0**	**0**
Chlorococcus,	0	0	0	0	0	6	9	44	0	9	0	0
Hyalotheca,	0	0	0	0	0	3	19	0	0	0	0	0
Raphidium,	0	0	0	0	0	6	7	0	0	0	0	0
Selenastrum,	0	0	0	0	0	0	0	16	0	0	0	0
Fungi. Crenothrix,	**1**	**0**	**pr.**	**4**	**6**	**2**	**5**	**48**	**28**	**7**	**1**	**1**
ANIMALS.												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**pr.**	**pr.**	**0**	**0**
Infusoria,	**pr.**	**0**	**5**	**15**	**5**	**10**	**7**	**2**	**9**	**2**	**0**	**0**
Cryptomonas,	0	0	0	0	0	0	0	2	0	0	0	0
Dinobryon,	0	0	5	11	4	0	0	0	9	0	0	0
Dinobryon cases,	0	0	0	3	1	8	pr.	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	2	0	0
Peridinium,	pr	0	0	1	0	2	7	0	0	0	0	0
Miscellaneous. Zoöglœa,	**54**	**68**	**76**	**8**	**204**	**262**	**196**	**88**	**66**	**84**	**132**	**9**
TOTAL,	65	79	120	66	325	550	275	344	109	168	151	35

LOWELL.

Chemical Examination of Water from the Filter-Gallery and Filter-Bed of the Lowell Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9015	June 17	June 18	Distinct.	Heavy, rusty.	0.30	6.90	.0456	*.0058 .0044	.29	.0400	.0001	3.2	-
9016	June 17	June 18	Slight.	Slight.	0.90	6.35	.0330	*.0064 .0052	.22	.0180	.0002	3.0	-
9017	June 17	June 18	Distinct.	Cons., rusty.	0.40	7.30	.0316	*.0050 .0038	.28	.0450	.0004	3.4	-
9065	June 30	July 2	Slight.	Slight.	0.55	3.20	.0026	.0130	.13	.0090	.0000	0.9	-
9137	July 21	July 21	Decided.	Heavy, rusty.	†	8.10	.0530	.0034	.26	.0350	.0020	3.6	1.0524

Odor of No. 9015, offensive; of No. 9016, musty and disagreeable; of No. 9017, none; of No. 9065, faintly vegetable; and of No. 9137, faintly unpleasant. —— The first three samples were collected respectively from the filter-gallery at the upper manhole, from the filter-gallery at the inlet chamber, and from the pump well at the pumping station, after the direct connection with the Merrimack River had been closed for twenty-four hours. No. 9065 was filtered water from the filter-bed. The surface of the bed was cleaned three days before this sample was collected, and the filtration was very rapid. No 9137, like No. 9015, was collected from the filter-gallery at the upper manhole.

* These determinations were made upon the water before filtration through filter paper.

† The color of this sample was not determined, on account of the turbidity of the water.

Microscopical Examination.

[Number of organisms per cubic centimeter.]

	1892. June.	1892. June.	1892. June.	1892. July.	1892. July.
Day of examination,	18	18	18	2	22
Number of sample,	9015	9016	9017	9065	9137
PLANTS.					
Diatomaceæ. Synedra,	0	0	6	1	0
Fungi. Crenothrix,	432	260	15	30	124
Miscellaneous. Zoöglœa,	0	120	64	0	472
Total,	432	380	85	31	596

First Pumping Test, from Wells on the North Bank of the Merrimack River near the Old Ferry Road.

These wells were located just east of the Old Ferry Road about 100 feet from the river and about 6,500 feet above the upper end of the filter-gallery. They were two inches in diameter, and were driven to an average depth of 26.7 feet. The extreme wells were about 100 feet apart. The material encountered was river silt to a depth of 19 feet, beneath which was a stratum of coarse sand and then quicksand.

LOWELL.

At first six wells were pumped for forty hours, yielding 482,884 gallons.

Then eight wells were pumped for sixteen hours, yielding 374,389 gallons.

Finally, ten wells were connected, and after pumping during the daytime for a week, with a total yield of 1,550,789 gallons, a continuous pumping test was begun August 29 at 4 P.M., and was continued until September 8 at 11.20 A.M., the amount pumped averaging 486,905 gallons per twenty-four hours.

Samples of water were collected for analysis at intervals during the test, and the results are given in the following table. They show the presence of a large amount of free ammonia, which increased during the test, and was accompanied by a considerable amount of iron, indicating that the water had been in contact with decomposing organic matter in the ground.

Chemical Examination of Samples of Water collected during a Pumping Test of Tubular Wells on the North Bank of the Merrimack River, just East of the Old Ferry Road.

[Parts per 100,000.]

Number of Wells Connected.	Number of Sample.	Date of		Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
		Collection.	Examination.	Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.		Nitrates.	Nitrites.		
		1892.														
6	9226	Aug. 10, 11. A.M.	Aug. 11	V. sl't, milky.	None.	0.0	None.	None.	5.75	.0086	.0000	.44	.0650	.0001	2.6	.0350
6	9241	Aug. 12, 4.30 P.M.	Aug. 13	V. sl't.	None.	0.0	None.	None.	5.80	.0222	.0012	.41	.1000	.0000	2.7	.0600
10	9275	Aug. 18, 5.15 P.M.	Aug. 19	V. sl't, milky.	None.	0.0	F't, unpleas't.	None.	5.65	.0280	.0000	.50	.0700	.0001	3.0	.1550
10	9320	Aug. 30, 5 10 P.M.	Aug. 31	None.	None.	0.0	None.	None.	6.70	.0344	.0000	.40	.0450	.0002	2.4	.2500
10	9322	Aug. 31, 5.15 P.M.	Sept. 1	None.	None.	0.0	None.	None.	6.75	.0362	.0014	.42	.0400	.0002	3.3	.2350
10	9344	Sept. 2, 5.10 P.M.	Sept. 3	None.	None.	0.0	None.	None.	6.75	.0480	.0012	.42	.0300	.0002	2.6	.2250
10	9348	Sept. 6, 10.30 A.M.	Sept. 6	V. sl't, milky.	V. sl't.	0.0	V. f'nt, or none.	F't, peculiar.	6.85	.0480	.0004	.39	.0280	.0001	2.9	.2250

The turbidity of Nos. 9344 and 9348 became distinct after the samples had been standing in the laboratory for a day or two A rusty sediment was at the same time deposited on the bottom of the bottles.

The color of these samples was observed again, after they had remained for a time in the laboratory, to determine the amount of increase on standing, with the following results: No. 9226, after one day, 0.02; No. 9241, two days, 0 02; No. 9275, one day, 0.12; No. 9320, one day, 0.03; three days, 0.10; four days, 0.18; No. 9322, one day, 0.08; three days, 0.20; No. 9344, one day, 0.02; No. 9348, one day, 0.10; two days, 0.40.

LOWELL.

Microscopical Examination of Samples of Water collected during a Pumping Test of Wells on the North Bank of the Merrimack River, just East of the Old Ferry Road.

[Number of organisms per cubic centimeter.]

	1892.						
	Aug.	Aug.	Aug.	Aug.	Aug.	Sept.	Sept.
Day of examination,	12	13	19	30	31	8	8
Number of sample,	9226	9241	9275	9320	9322	9344	9348
PLANTS.							
Diatomaceæ. Tabellaria,	0	0	0	-	-	4	0
Infusoria. Dinobryon cases,	0	0	0	-	-	18	0
Miscellaneous,	0	2	0	-	-	484	544
Zoöglœa,	0	2	0	-	-	0	0
Iron rust,	0	0	0	-	-	484	544
TOTAL,	0	2	0	-	-	506	544

Second Pumping Test, from Wells on the North Bank of the Merrimack River near the Upper End of the Pawtucket Boulevard.

These wells were located about 1,500 feet west of those last described, in somewhat higher ground, at a distance of about 200 feet from the river. The average depth of the wells was 31 feet, and the sand penetrated was said to be free from the rusty color which was characteristic at the first location.

At first six wells were pumped twenty-two hours and thirty-two minutes, yielding 186,382 gallons.

Then eight wells were pumped sixteen hours and thirty-three minutes, on September 18 and 19, yielding 167,537 gallons.

Finally ten wells were pumped from September 20 to October 3, and between these dates a continuous run of nine days, twenty-one hours and ten minutes was made, yielding an average of 458,337 gallons per twenty-four hours.

Samples of water for analysis were collected at intervals during the test, and the results may be found in the following table.

LOWELL.

Chemical Examination of Samples of Water collected during a Pumping Test of Tubular Wells on the North Bank of the Merrimack River near the Upper End of the Pawtucket Boulevard, Lowell.

[Parts per 100,000.]

Number of Wells Connected.	Number of Sample.	Date of Collection.	Date of Examination.	Appearance. Turbidity and Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
		1892.											
6	9364	Sept. 13, 5.20 P.M.	Sept. 14	None.	0.0	4.50	.0000	.0006	.32	.1500	.0000	1.6	.0350
6	9386	Sept. 16, 5.10 P.M.	Sept. 17	None.	0.0	4.75	.0000	.0000	.33	.0900	.0000	1.7	.0075
8	9400	Sept. 19, 4.00 P.M.	Sept. 20	None.	0.0	4.65	.0000	.0000	.36	.0700	.0000	1.7	.0100
10	9422	Sept. 22, 7.10 A.M.	Sept. 23	None.	0.0	5.15	.0000	.0016	.35	.0800	.0000	1.8	.0100
10	9478	Sept. 30, 5.25 P.M.	Oct. 1	None.	0.0	5.10	.0004	.0000	.31	.0780	.0001	2.7	-
10	9488	Oct. 3, 8.10 A.M.	Oct. 4	None.	0.0	4.80	.0000	.0000	.32	.0800	.0001	2.3	-

Odor, none.

Microscopical Examination.

No organisms.

Third Pumping Test, from Wells at the City Farm in the Valley of River Meadow Brook.

These wells, averaging 35 feet in depth, were located in the vicinity of the brook.

Six wells were pumped nine hours and twenty-four minutes on October 31, yielding 146,706 gallons.

Then seven wells were pumped, on November 7 and 8, for eighteen hours and thirty-six minutes, yielding 291,997 gallons.

Beginning again on November 9, the seven wells were pumped continuously for a period of seventy-three hours and forty-four minutes, the total amount of water pumped being 1,353,989 gallons, or an average of 440,640 gallons per twenty-four hours.

Samples of water for analysis were collected at intervals during this test, and the results are given in the following table.

Chemical Examination of Samples of Water collected during a Pumping Test of Tubular Wells located at the City Farm in the Valley of River Meadow Brook, Lowell.

[Parts per 100,000.]

Number of Wells Connected.	Number of Sample.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
		1892.												
6	9597	Oct. 31	Nov. 1	None.	None.	0.0	7.25	.0000	.0000	.54	.1100	.0000	3.0	.0020
7	9650	Nov. 9	Nov. 10	None.	None.	0.0	7.25	.0000	.0010	.51	.1100	.0000	3.4	.0000
7	9664	Nov. 12	Nov. 14	None.	None.	0.0	7.60	.0000	.0000	.53	.1200	.0000	3.7	.0000

Microscopical Examination.

No. 9597, no organisms. No. 9650, Miscellaneous, *Zoōglœa*, 22. No. 9664, Miscellaneous, *Zoōglœa*, 17.

LOWELL.

Tests of Individual Wells.

All of the individual wells from which either chemical or bacterial samples were collected are included in the following table, which gives their location and depth, and the material in which they were driven.

Number of Well.	Distance above Upper End of Filter-gallery. Feet.	Distance from Merrimack River. Feet.	Depth of Well. Feet.	Thickness of Strata (Feet). River Silt (at Surface).	Sand.	Quick-sand.	Gravel.
Barker, No. 4, ...	6,900	260	72.7	44	-	22	6.7
Pierce, No. 2, ...	6,900	240	29.1	20	12	-	-
Pierce, No. 3, ...	6,600	160	26.8	19.5	10.5	-	-
Pierce, No. 4, ...	7,400	320	36.2	23.5	12	-	-
Pierce, No. 5, ...	5,800	75	20.0	11	9	-	-
Andrews, No. 22, . . .	7,100	280	-	-	-	-	-
Andrews, No. 23, . . .	7,700	350	-	-	-	-	-
Andrews, No. 26, . . .	6,500	100	-	-	-	-	-
Andrews, No. 1*, . . .	-	-	45.0	-	-	-	-
Andrews, No. 5*, . . .	-	-	39.0	-	-	-	-

* These wells were located in the valley of River Meadow Brook.

Chemical Examination of Water from Pierce Wells Nos. 4 and 5 on the North Bank of the Merrimack River.

[Parts per 100,000.]

Number of Well.	Number of Sample.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Hardness.
		1891.											
4	8254	Nov. 10	Nov. 11	V. sl't.	Cons. sand.	0.0	9.70	.0000	.0026	1.06	.4000	.0001	3.6
		1892.											
4	8440	Jan. 20	Jan. 21	V. sl't, clayey.	Cons. sand.	0.0	-	.0012	.0008	.68	.3032	.0005	-
4	8441	Jan. 20	Jan. 21	None.	Cons. sand.	0.0	-	.0000	.0006	.81	.3365	.0001	-
4	8442	Jan. 20	Jan. 21	None.	Cons. sand.	0.0	-	.0000	.0006	.84	.3370	.0001	-
4	8443	Jan. 20	Jan. 21	None.	Cons. sand.	0.0	-	.0000	.0006	.88	.3265	.0001	-
4	8444	Jan. 20	Jan. 21	None.	Cons. sand.	0.0	8.20	.0000	.0000	.91	.3440	.0001	3.1
5	8445	Jan. 20	Jan. 21	None.	Cons. sand.	0.0	8.20	.0000	.0006	.88	.3050	.0001	3.0

Odor, none.——The samples were obtained by pumping with a hand pump. On January 20, pumping was continued for several hours, and the samples were collected at the following intervals after pumping began: No. 8440, seven minutes; No. 8441, one hour; No. 8442, two hours; No. 8443, four hours; No. 8444, five hours; No. 8445, from Pierce Well No. 5, was obtained after pumping three hours.

Microscopical Examination.

Only three of the samples, Nos. 8254, 8444 and 8445, were examined microscopically, and no organisms were found.

LOWELL.

Chemical Examination of Water from Andrews Wells, Nos. 22, 23 and 26, on the North Bank of the Merrimack River, and Nos. 1 and 5 near River Meadow Brook.

[Parts per 100,000.]

Number of Well.	Number of Sample.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
		1892.												
22	9273	Aug. 18	Aug. 19	None.	V. sl't, sand.	0.0	6.25	.0002	.0000	.80	.1000	.0000	3.1	.0060
23	9274	Aug. 18	Aug. 19	None.	Slight, sand.	0.0	5.90	.0000	.0000	.70	.2000	.0000	3.0	.0300
26	9345	Sept. 3	Sept. 3	None.	None.	0.0	7.20	.0020	.0004	.40	.0400	.0004	2.7	.0750
1	9430	Sept. 23	Sept. 24	None.	V. sl't.	0.0	5.05	.0000	.0000	.28	.0700	.0000	1.4	.0125
5	9503	Oct. 7	Oct. 8	None.	V. sl't.	0.0	7.90	.0000	.0004	.52	.1300	.0000	2.9	.0100

Odor, none.—— The samples were collected by pumping from the wells with a hand pump.

Microscopical Examination.

Nos. 9273, 9274 and 9503, no organisms; No. 9345, Tabellaria, 200; starch grains, 50. No. 9430, not examined.

Bacterial Examinations.

The first sample was taken from Pierce Well No. 4 on Nov. 10, 1891, and the number of bacteria found was 272 per cubic centimeter. This was an unusually large number to find in water taken from a driven well, and further samples were collected on Dec. 2, 1891, and Jan. 8, 1892. A portable hand pump was used to draw the water, and in some instances samples were also collected directly from the wells. The results are as follows: —

Source of Sample.	Date and Hour of Collection.	Bacteria per Cubic Centimeter. Samples Collected by pumping.	Bacteria per Cubic Centimeter. Samples Collected directly from Wells.
Pierce Well No. 2,	Dec. 2, 1891,	Liquefied,	920
Pierce Well No. 3,	Dec. 2, 1891,	4	21
Pierce Well No. 4,	Dec. 2, 1891,	106	1,250
Pierce Well No. 5,	Dec. 2, 1891,	29	93
Barker Well No. 4,	Dec. 2, 1891,	52	47
Pierce Well No. 2,	Jan. 8, 1892,	1,960	-
Pierce Well No. 3,	Jan. 8, 1892,	19	-
Pierce Well No. 4,	Jan. 8, 1892, 11.36 A.M.,	30	-
Pierce Well No. 4,	Jan. 8, 1892, 11.41 A.M.,	1,210	-
Pierce Well No. 4,	Jan. 8, 1892, 11.46 A.M.,	348	-
Pierce Well No. 5,	Jan. 8, 1892,	22	-
Barker Well No. 4,	Jan. 8, 1892,	5	-

The results as given in the foregoing table verified the original test by showing a very large number of bacteria for a ground water; but, as there was some suspicion that this might be owing to the bacterial contamination of the pump and the water in the well, another test was made of one of the wells, taking the utmost care to prevent the introduction of bacteria from any foreign source, and the results are given in the table below. The pump used was thoroughly washed with corrosive sublimate and then with boiled water, and boiled water was used to start the pump. The well itself could not be freed from any accumulation of bacteria in the beginning, and the pumping was therefore continued for five hours to insure the collection of a satisfactory sample. The samples were taken every half-hour, and it is obvious that if any bacteria were being washed from the sides of the well or from any sediment which might have accumulated at the bottom of the well the numbers should decrease with continued pumping; but they did not decrease, from which it is evident that the bacteria actually came from the water in the ground. The last sample was collected at 3.00 p.m., and the gelatine plates, upon which the bacteria were grown, were planted the same day, beginning at 4.45 p.m.

Date and Hour of Collection.	Bacteria per Cubic Centimeter.	Molds per Cubic Centimeter.	Date and Hour of Collection.	Bacteria per Cubic Centimeter.	Molds per Cubic Centimeter.
1892.			**1892.**		
Jan. 20, 10.00 A.M. .	280	0	Jan. 20, 1.00 P.M. .	294	0
Jan. 20, 10.30 A.M. .	438	0	Jan. 20, 1.30 P.M. .	426	0
Jan. 20, 11.00 A.M. .	315	0	Jan. 20, 2.00 P.M. .	210	0
Jan. 20, 11.30 A.M. .	474	0	Jan. 20, 2.30 P.M. .	1,122	0
Jan. 20, 12.00 M. .	417	0	Jan. 20, 3.00 P.M. .	618	0
Jan. 20, 12.30 P.M. .	480	0			

A bacterial examination was also made of the water of the gang of driven wells in the valley of River Meadow Brook during the last day of the pumping test described on page 162. The results of this examination are as follows: —

LOWELL.

Bacterial Examination of Water from a Gang of Seven Test Wells located at the City Farm in the Valley of River Meadow Brook, Lowell.

Bacterial Number.	Date and Hour of Collection.	Date and Hour of Planting.	Bacteria per Cubic Centimeter.	Molds per Cubic Centimeter.
	Nov. 12, 1892.	Nov. 12, 1892.		
1090,	10.15 A.M.	6 P.M.	2	0
1081,	10.56 A.M.	6 P.M.	2	0
1085,	12.55 P.M.	6 P.M.	1	0
1088,	1.25 P.M.	6 P.M.	2	0
1087,	1.45 P.M.	6 P.M.	1	0

These samples were grown on gelatine plates for forty-eight hours, at 19°–23° C.

Water Supply of Ludlow.

(See *Springfield.*)

Water Supply of Lynn.

Chemical Examination of Water from Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8407	Jan. 7	Jan. 8	Distinct.	Cons.	0.60	3.80	1.50	.0006	.0242	.0184	.0058	.45	.0090	.0000	0.6
8491	Feb. 8	Feb. 9	Slight.	Slight.	0.50	4.10	1.35	.0004	.0210	.0168	.0042	.54	.0100	.0003	1.0
8589	Mar. 8	Mar. 9	Slight.	Slight.	0.70	4.10	1.60	.0016	.0242	.0210	.0032	.59	.0070	.0000	0.6
8733	Apr. 12	Apr. 13	V. slight.	Slight.	0.30	3.70	1.30	.0000	.0156	.0138	.0018	.48	.0050	.0000	0.6
8872	May 9	May 10	V. slight.	Slight.	0.28	3.50	1.60	.0000	.0182	.0168	.0014	.50	.0030	.0000	0.8
8972	June 6	June 7	Distinct.	Cons., white.	0.40	3.65	1.40	.0000	.0186	.0134	.0052	.52	.0000	.0000	0.5
9083	July 11	July 12	Slight.	Slight.	0.30	3.45	1.30	.0002	.0264	.0180	.0084	.52	.0030	.0000	0.8
9210	Aug. 8	Aug. 9	Slight.	Slight.	0.25	3.10	1.15	.0000	.0200	.0164	.0036	.54	.0030	.0001	1.1
9360	Sept. 12	Sept. 13	Slight.	Slight.	0.30	3.45	1.45	.0000	.0214	.0190	.0024	.44	.0090	.0000	1.6
9510	Oct. 10	Oct. 12	Slight.	Slight.	0.30	3.40	0.50	.0000	.0280	.0238	.0042	.48	.0050	.0000	1.1
9660	Nov. 9	Nov. 10	Slight.	Slight.	0.50	3.90	1.90	.0024	.0236	.0168	.0068	.47	.0000	.0001	1.6
9771	Dec. 7	Dec. 9	Slight.	Cons., brown.	0.70	3.70	1.50	.0000	.0228	.0178	.0050	.41	.0120	.0000	1.7
Av.	....	....	....	....	0.43	3.65	1.38	.0004	.0220	.0177	.0043	.49	.0055	.0000	1.0

Odor, vegetable, frequently also unpleasant or disagreeable; on heating, the odor is generally somewhat stronger. —— The samples were collected from the pond near the gate-house, generally about one foot beneath the surface.

LYNN.

Microscopical Examination of Water from Breed's Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	10	10	14	11	8	12	9	13	12	11	9
Number of sample,	8407	8491	8589	8733	8872	8972	9083	9210	9360	9510	9660	9771
PLANTS.												
Diatomaceæ,	**268**	**8**	**24**	**59**	**343**	**2,644**	**811**	**224**	**178**	**128**	**18**	**21**
Asterionella,	8	0	0	11	0	8	4	8	2	0	2	5
Diatoma,	0	0	0	0	0	0	7	4	32	28	0	0
Melosira,	4	7	0	0	8	0	0	0	20	12	2	0
Synedra,	34	1	24	29	27	4	0	0	0	10	6	13
Tabellaria,	222	0	0	19	308	2,632	800	212	124	78	8	3
Cyanophyceæ,	**8**	**20**	**0**	**0**	**1**	**8**	**56**	**2**	**0**	**216**	**6**	**1**
Anabæna,	0	0	0	0	1	8	56	2	0	208	0	1
Chroöcoccus,	8	20	0	0	0	0	0	0	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	0	0	8	0	0
Algæ,	**64**	**42**	**0**	**17**	**2**	**17**	**1**	**55**	**8**	**4**	**1**	**0**
Chlorococcus,	0	0	0	8	0	16	0	0	4	0	0	0
Raphidium,	0	0	0	7	2	0	0	50	0	4	0	0
Staurastrum,	0	0	0	0	0	1	1	5	4	0	1	0
Zoöspores,	64	42	0	2	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	**4**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Rhizopoda,	**pr.**	**1**	**5**	**4**	**3**	**0**	**pr.**	**0**	**1**	**4**	**5**	**0**
Actinophrys,	pr.	1	5	4	3	0	pr.	0	1	2	2	0
Arcella,	0	0	0	0	0	0	0	0	0	0	3	0
Difflugia,	0	0	0	0	0	0	0	0	0	2	0	0
Infusoria,	**100**	**85**	**6**	**22**	**14**	**0**	**69**	**19**	**13**	**34**	**1**	**1**
Dinobryon,	31	50	4	0	0	0	0	0	0	0	0	0
Dinobryon cases,	24	6	0	9	6	0	1	3	10	0	0	0
Glenodinium,	0	0	0	0	0	0	5	0	0	0	0	0
Monas,	pr.	0	0	pr.	0	0	0	0	0	2	1	0
Peridinium,	45	28	2	13	8	0	58	15	2	2	0	1
Trachelomonas,	0	1	pr.	0	0	0	5	1	10	30	0	0
Vermes,	**4**	**1**	**0**	**0**	**7**	**1**	**1**	**1**	**0**	**0**	**0**	**0**
Anurea,	2	0	0	0	6	0	1	0	0	0	0	0
Polyarthra,	2	1	0	0	0	1	pr.	0	0	0	0	0
Sacculus,	0	0	0	0	1	0	0	1	0	0	0	0
Miscellaneous. Zoöglœa,	**71**	**3**	**2**	**9**	**15**	**2**	**40**	**76**	**192**	**0**	**52**	**88**
TOTAL,	519	160	37	112	387	2,672	978	377	401	386	77	111

LYNN.

Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8409	Jan. 7	Jan. 8	Slight.	Slight.	0.60	4.40	2.00	.0000	.0436	.0336	.0100	.44	.0050	.0000	0.8
8492	Feb. 8	Feb. 9	Distinct.	Slight.	0.55	4.45	1.80	.0000	.0318	.0242	.0076	.53	.0250	.0003	1.0
8588	Mar. 8	Mar. 9	Slight.	Slight.	0.15	3.70	1.50	.0042	.0210	.0158	.0052	.69	.0070	.0001	0.6
8732	Apr. 12	Apr. 13	Slight.	Slight.	0.15	3.80	1.40	.0012	.0274	.0208	.0066	.44	.0050	.0001	0.8
8873	May 9	May 10	Slight.	Slight.	0.15	3.05	1.35	.0000	.0214	.0160	.0054	.46	.0030	.0000	1.1
8973	June 6	June 7	Distinct.	Cons., white.	0.25	3.50	1.15	.0030	.0258	.0150	.0108	.48	.0000	.0000	0.8
9084	July 11	July 12	Slight.	Slight.	0.23	3.10	1.60	.0014	.0320	.0230	.0090	.44	.0050	.0001	0.9
9209	Aug. 8	Aug. 9	Slight.	Slight, green.	0.50	3.40	1.45	.0000	.0236	.0216	.0020	.47	.0030	.0001	1.3
9359	Sept. 12	Sept. 13	Distinct.	Cons., rusty.	0.60	3.55	1.65	.0000	.0282	.0214	.0068	.45	.0070	.0002	0.8
9511	Oct. 10	Oct. 12	Distinct.	Cons., brown.	0.80	3.45	1.45	.0056	.0334	.0252	.0082	.45	.0100	.0001	1.0
9661	Nov. 9	Nov. 10	Distinct.	Cons., green.	1.10	3.90	1.75	.0030	.0334	.0278	.0056	.44	.0180	.0001	1.3
9772	Dec. 7	Dec. 9	Distinct, green.	Cons., green.	0.70	4.50	1.65	.0008	.0368	.0278	.0090	.41	.0220	.0001	2.1
Av.	....	......	....	....	0.48	3.73	1.56	.0016	.0299	.0227	.0072	.47	.0092	.0001	1.0

Odor, generally vegetable, frequently unpleasant or disagreeable; on heating, the odor is vegetable and grassy, or sweetish.——The samples were collected from the pond near the gate-house, one foot beneath the surface.

Microscopical Examination of Water from Birch Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	10	10	14	11	8	12	9	13	12	11	9
Number of sample,	8409	8492	8588	8732	8873	8973	9084	9209	9359	9511	9661	9772
PLANTS.												
Diatomaceæ,	**204**	**35**	**7**	**204**	**1,037**	**1,195**	**95**	**131**	**401**	**344**	**365**	**51**
Asterionella,	14	4	0	16	764	2	7	27	0	0	11	15
Diatoma,	0	1	0	0	4	4	0	23	8	2	0	0
Melosira,	0	3	0	1	12	10	0	0	33	184	272	0
Navicula,	pr.	0	0	4	1	1	0	0	0	2	2	0
Synedra,	128	27	7	162	132	26	0	3	0	4	8	36
Tabellaria,	62	0	0	21	124	1,152	88	78	360	152	72	0

Microscopical Examination of Water from Birch Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	**1**	**0**	**0**	**52**	**0**	**226**	**45**	**85**	**80**	**50**	**0**	**1**
Anabæna,	0	0	0	0	0	220	12	9	53	0	0	1
Aphanocapsa,	0	0	0	pr.	0	1	3	42	5	0	0	0
Chroöcoccus,	1	0	0	52	0	0	0	0	4	0	0	0
Clathrocystis,	0	0	0	0	0	1	7	33	12	4	0	0
Cœlosphærium,	0	0	0	0	0	0	21	0	6	6	0	0
Homolococcus,	0	0	0	0	0	0	0	0	0	40	0	0
Microcystis,	0	0	0	0	0	4	2	1	0	0	0	0
Algæ,	**5**	**0**	**3**	**32**	**13**	**10**	**16**	**39**	**174**	**0**	**3**	**14**
Chlorococcus,	2	0	0	0	8	0	0	24	22	0	0	0
Closterium,	1	0	0	2	2	4	3	0	0	0	0	2
Nephrocytium,	0	0	0	0	0	0	4	0	80	0	0	4
Protococcus,	0	0	0	0	0	0	0	0	60	0	0	0
Raphidium,	0	0	0	15	0	0	4	12	8	0	0	2
Scenedesmus,	0	0	0	4	0	0	0	1	1	0	3	1
Staurastrum,	0	0	0	0	2	6	5	2	2	0	0	0
Zoöspores,	2	0	3	11	1	0	0	0	1	0	0	5
Fungi. Crenothrix,	**8**	**0**	**pr.**	**1**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**0**
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**3**	**1**	**0**	**1**	**0**	**1**	**2**	**146**	**0**
Actinophrys,	0	0	0	3	1	0	1	0	1	0	6	0
Arcella,	0	0	0	0	0	0	0	0	0	2	140	0
Infusoria,	**38**	**19**	**4**	**198**	**2**	**0**	**73**	**3**	**722**	**44**	**3**	**272**
Cryptomonas,	0	0	0	3	0	0	0	0	0	0	0	0
Dinobryon,	22	4	1	68	0	0	0	0	440	0	0	0
Dinobryon cases,	2	0	0	80	0	0	13	2	276	32	0	0
Gonium,	0	0	0	2	0	0	0	0	0	0	0	0
Monas,	1	0	0	2	1	0	0	0	0	0	2	0
Peridinium,	13	15	3	40	1	0	54	1	0	2	1	272
Trachelomonas,	pr.	0	0	3	0	0	6	0	5	2	0	0
Vorticella,	0	0	0	0	0	0	0	0	1	8	0	0
Vermes,	**2**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**2**	**0**	**0**
Anurea,	2	0	1	0	0	0	1	0	0	0	0	0
Monocerca,	0	0	0	0	0	0	0	0	0	2	0	0
Polyarthra,	pr.	0	0	0	0	1	0	0	0	0	0	0
Crustacea. Cyclops,	**0**	**.04**	**.17**	**0**	**.01**	**0**	**0**	**0**	**0**	**0**	**0**	**.02**
Miscellaneous. Zoöglœa,	**0**	**0**	**0**	**104**	**20**	**100**	**92**	**0**	**284**	**296**	**64**	**40**
TOTAL,	258	54	14	594	1,073	1,533	323	258	1,662	740	581	378

LYNN.

Chemical Examination of Water from Walden Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8408	Jan. 7	Jan. 8	Decided.	Cons.	0.80	5.25	2.75	.0000	.0644	.0422	.0222	.41	.0250	.0001	0.6
8489	Feb. 8	Feb. 9	Slight.	Slight.	0.80	4.15	2.30	.0012	.0450	.0342	.0108	.41	.0250	.0005	0.6
8587	Mar. 8	Mar. 9	Slight.	Cons., green.	1.20	4.00	2.00	.0032	.0282	.0162	.0120	.41	.0070	.0000	0.3
8731	Apr. 12	Apr. 13	Distinct.	Cons.	0.55	3.85	1.35	.0012	.0442	.0280	.0162	.41	.0020	.0000	0.5
8871	May 9	May 10	Decided.	Heavy, green.	0.60	3.50	1.80	.0000	.0570	.0288	.0282	.39	.0050	.0000	0.6
8970	June 6	June 7	Distinct.	Cons., white.	0.90	4.30	1.90	.0496	.0420	.0330	.0090	.38	.0050	.0002	0.2
9086	July 11	July 12	Decided, green.	Cons., green.	1.00	4.70	2.30	.0028	.1356	.0468	.0888	.38	.0050	.0000	0.6
9212	Aug. 8	Aug. 9	Decided, green.	Heavy, rusty.	1.00	5.55	3.10	.0004	.0946	.0476	.0470	.48	.0050	.0001	0.8
9357	Sept. 12	Sept. 13	Distinct, green.	Cons., green.	0.90	6.30	3.80	.0008	.0736	.0488	.0248	.36	.0120	.0003	0.5
9509	Oct. 10	Oct. 12	Decided.	Cons., green.	0.90	5.60	3.00	.0000	.0632	.0456	.0176	.44	.0030	.0000	0.8
9662	Nov. 9	Nov. 10	Slight.	Cons.	0.90	5.35	3.10	.0382	.0512	.0424	.0088	.40	.0150	.0001	0.6
9773	Dec. 7	Dec. 9	Slight.	Cons.	1.20	5.15	2.85	.0152	.0524	.0456	.0068	.40	.0300	.0001	1.3
Av.	....	....	....	....	0.90	4.81	2.50	.0094	.0626	.0383	.0243	.41	.0116	.0001	0.6

Odor, generally decidedly vegetable and unpleasant or disagreeable; on heating, the odor is somewhat stronger. —— The samples were collected from the pond near the gate-house, about one foot beneath the surface.

Microscopical Examination of Water from Walden Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	9	10	10	14	11	8	12	9	13	12	11	9
Number of sample,	8408	8489	8587	8731	8871	8970	9086	9212	9357	9509	9662	9773
PLANTS.												
Diatomaceæ,	17	22	7	2	120	18	0	15	3	2	87	216
Asterionella,	pr.	0	0	2	60	0	0	0	0	0	80	4
Diatoma,	pr.	0	0	0	0	1	0	0	0	0	0	124
Fragilaria,	1	15	0	0	0	0	0	0	0	0	0	6
Melosira,	3	4	0	0	0	0	0	0	0	0	4	0
Navicula,	1	0	0	0	3	0	0	0	1	0	1	2
Nitzschia,	0	0	0	0	0	0	0	0	0	0	0	18
Synedra,	11	3	6	0	1	17	0	15	0	0	1	16
Tabellaria,	1	0	1	0	56	0	0	0	2	2	1	46

LYNN.

Microscopical Examination of Water from Walden Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	**11**	**12**	**6**	**19**	**625**	**7**	**16,215**	**3,650**	**413**	**212**	**3**	**6**
Anabæna,	0	0	pr.	4	616	0	15,600	550	34	0	0	0
Chroöcoccus,	0	0	0	4	0	0	15	0	0	0	0	0
Clathrocystis,	11	12	3	11	9	2	400	1,000	336	192	0	6
Cœlosphærium,	0	0	0	0	0	5	200	2,100	4	2	3	0
Microcystis,	0	0	3	0	0	0	0	0	39	18	0	0
Algæ,	**1,245**	**2,144**	**3,401**	**16**	**50**	**136**	**15**	**0**	**477**	**842**	**28**	**16**
Chlorococcus,	0	0	0	0	14	24	0	0	0	0	28	0
Closterium,	1	0	1	0	8	4	0	0	0	4	0	14
Pandorina,	0	0	0	0	0	3	5	0	0	0	0	0
Pediastrum,	0	0	0	1	28	1	0	0	3	0	0	0
Protococcus,	0	0	0	0	0	56	5	0	418	832	0	0
Selenastrum,	0	0	0	0	0	0	0	0	50	0	0	0
Sorastrum,	0	0	0	0	0	0	0	0	6	0	0	0
Staurastrum,	0	0	0	0	0	48	5	0	0	2	0	2
Zoöspores,	1,244	2,144	3,400	15	0	0	0	0	0	4	0	0
Fungi,	**1**	**0**	**0**	**1**	**0**	**5**	**0**	**0**	**100**	**12**	**0**	**2**
Cladothrix,	0	0	0	0	0	0	0	0	100	0	0	0
Crenothrix,	1	0	0	1	0	5	0	0	0	12	0	2
ANIMALS.												
Rhizopoda,	**1**	**1**	**0**	**2**	**1**	**0**	**0**	**0**	**2**	**2**	**0**	**1**
Actinophrys,	1	0	0	2	1	0	0	0	0	0	0	1
Arcella,	0	0	0	0	0	0	0	0	0	2	0	0
Difflugia,	0	1	0	0	0	0	0	0	2	0	0	0
Infusoria,	**40**	**76**	**5**	**93**	**265**	**1**	**15**	**0**	**137**	**44**	**3**	**12**
Chloromonas,	0	70	0	0	0	0	0	0	0	0	0	0
Codonella,	0	0	0	2	0	0	0	0	0	0	0	0
Cryptomonas,	0	0	4	33	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	14	2	0	0	0	0	0	0	0
Monas,	pr.	1	0	4	1	0	0	0	0	0	0	0
Pandorina,	0	0	0	0	3	0	0	0	0	0	0	0
Peridinium,	38	5	pr.	21	1	0	0	0	1	0	0	11
Synura,	0	0	0	5	256	1	0	0	0	0	0	0
Trachelomonas,	0	0	1	2	2	0	15	0	136	44	3	1
Uroglena,	2	0	0	12	0	0	0	0	0	0	0	0
Vermes,	**4**	**2**	**0**	**pr.**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Anurea,	1	0	0	0	1	0	0	0	0	0	0	0
Monocerca,	1	0	0	pr.	0	0	0	0	0	0	0	0
Polyarthra,	pr.	0	0	0	2	0	0	0	0	0	0	0
Rotatorian ova,	2	0	0	0	0	0	0	0	0	0	0	0
Sacculus,	0	2	0	0	0	0	0	0	0	0	0	0
Crustacea,	**1**	**0**	**0**	**.02**	**.44**	**.02**	**0**	**0**	**.18**	**.04**	**0**	**.16**
Cyclops,	0	0	0	.02	.24	.02	0	0	.16	0	0	.10
Daphnia,	0	0	0	0	.20	0	0	0	.02	.04	0	0
Diaptomus,	0	0	0	0	0	0	0	0	0	0	0	.06
Entomostracan ova,	1	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**pr.**	**14**	**1**	**2**	**320**	**56**	**0**	**0**	**164**	**12**	**44**	**80**
TOTAL,	1,320	2,277	3,420	135	1,384	223	16,245	365	1,296	1,126	165	333

LYNN.

Chemical Examination of Water from Glen Lewis Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8410	Jan. 7	Jan. 8	Slight.	Cons., green.	0.80	4.15	2.00	.0102	.0546	.0372	.0174	.37	.0600	.0001	0.3
8490	Feb. 8	Feb. 9	Slight.	Slight.	0.55	3.35	1.75	.0014	.0932	.0448	.0484	.43	.0350	.0005	0.5
8590	Mar. 8	Mar. 9	V. slight.	Slight.	0.40	3.60	1.70	.0274	.0302	.0228	.0074	.44	.0300	.0001	0.2
8730	Apr. 12	Apr. 13	Slight.	Cons., green.	0.50	3.80	1.85	.0006	.0484	.0302	.0182	.40	.0020	.0001	0.5
8870	May 9	May 10	Distinct.	Cons.	0.50	3.50	1.85	.0058	.0310	.0252	.0058	.38	.0120	.0000	1.0
8971	June 6	June 7	Distinct.	Slight.	0.50	3.85	1.60	.0064	.0342	.0262	.0080	.41	.0120	.0002	0.2
9085	July 11	July 12	Slight.	Cons.	0.70	3.95	1.60	.0026	.0510	.0350	.0160	.46	.0050	.0000	0.5
9211	Aug. 8	Aug. 9	Slight.	Slight, rusty.	0.50	4.05	2.00	.0040	.0328	.0300	.0028	.38	.0050	.0003	1.1
9358	Sept. 12	Sept. 13	Distinct, green.	Cons., rusty.	0.80	4.35	2.35	.0236	.0552	.0400	.0152	.36	.0120	.0003	1.6
9508	Oct. 10	Oct. 12	Slight.	Slight.	0.95	4.90	2.80	.0448	.0446	.0404	.0042	.37	.0200	.0007	0.6
Av.	....	....	....	....	0.62	3.95	1.95	.0127	.0475	.0332	.0143	.40	.0193	.0002	0.6

Odor, vegetable and often disagreeable. —— The samples were collected from the pond near the gate-house, one foot beneath the surface.

Microscopical Examination of Water from Glen Lewis Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.
Day of examination,	9	10	10	14	11	8	12	9	13	12
Number of sample,	8410	8490	8590	8730	8870	8971	9085	9211	9358	9508
PLANTS.										
Diatomaceæ,	**1**	**35**	**92**	**2**	**28**	**46**	**0**	**664**	**289**	**42**
Asterionella,	0	0	0	1	4	0	0	0	0	0
Diatoma,	0	0	90	0	4	0	0	0	0	0
Gomphonema,	0	0	0	0	5	0	0	0	0	0
Melosira,	0	8	0	0	0	0	0	660	288	30
Synedra,	1	27	2	1	15	46	0	0	1	4
Tabellaria,	0	0	0	0	0	0	0	4	0	8
Cyanophyceæ,	**0**	**0**	**0**	**pr.**	**66**	**66**	**218**	**23**	**299**	**24**
Anabæna,	0	0	0	pr.	0	66	0	4	76	0
Chroöcoccus,	0	0	0	0	0	0	26	0	0	0
Clathrocystis,	0	0	0	0	0	0	192	19	188	20
Microcystis,	0	0	0	0	0	0	0	0	35	40
Nostoc,	0	0	0	0	66	0	0	0	0	0

LYNN.

Microscopical Examination of Water from Glen Lewis Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1892.									
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.
PLANTS — Con.										
Algæ,	**2**	**0**	**1**	**3,104**	**4**	**0**	**184**	**18**	**9**	**44**
Pandorina,	0	0	0	0	0	0	108	0	0	0
Protococcus,	0	0	0	0	0	0	64	0	0	32
Staurastrum,	0	0	0	0	0	0	4	18	9	12
Tetraspora,	0	0	0	0	0	0	8	0	0	0
Zoöspores,	2	0	1	3,104	4	0	0	0	0	0
Fungi,	**42**	**0**	**0**	**0**	**2**	**19**	**0**	**0**	**40**	**22**
Cladothrix,	0	0	0	0	0	0	0	0	40	0
Crenothrix,	42	0	0	0	2	19	0	0	0	22
ANIMALS.										
Infusoria,	**pr.**	**1,520**	**2**	**365**	**9**	**27**	**8**	**2**	**6**	**4**
Chloromonas,	0	1,520	0	0	0	0	0	0	0	0
Cryptomonas,	0	0	0	27	0	0	0	0	0	0
Dinobryon,	0	0	0	2	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	0	26	8	0	0	0
Peridinium,	0	0	2	336	0	0	0	0	0	0
Rhipidodendron,	0	0	0	0	9	0	0	0	0	0
Trachelomonas,	pr.	0	0	0	0	1	0	2	6	4
Vermes,	**0**	**0**	**0**	**0**	**1**	**0**	**7**	**17**	**2**	**2**
Monocerca,	0	0	0	0	0	0	1	0	0	2
Rotatorian ova,	0	0	0	0	0	0	0	1	1	0
Rotifer,	0	0	0	0	1	0	2	0	1	0
Sacculus,	0	0	0	0	0	0	4	16	0	0
Miscellaneous. Zoöglœa,	**0**	**0**	**28**	**0**	**56**	**52**	**4**	**188**	**180**	**14**
TOTAL,	45	1,555	123	3,471	166	210	421	912	825	152

Table showing the Average Depth of Water in Feet in the Ponds and Storage Reservoirs of the Lynn Water Works during the Weeks in which Samples of Water were collected for Analysis.

WEEK ENDING —	Breed's Pond. High Water, 22.00 Feet.	Birch Pond. High Water, 21.50 Feet.	Walden Pond. High Water, 17.00 Feet.	Glen Lewis Pond. High Water, 17.00 Feet.
Jan. 9,	13.7	11.1	9.2	17.3
Feb. 13,	16.9	13.8	11.7	17.2
Mar. 12,	18.5	14.8	12.1	17.2
Apr. 16,	20.4	16.5	14.2	17.2
May 14,	20.4	17.0	13.6	17.3
June 11,	20.4	18.8	15.1	17.2
July 16,	17.4	18.6	14.0	17.1
Aug. 13,	16.5	14.4	13.7	17.2
Sept. 17,	14.8	10.2	13.5	17.1
Oct. 15,	12.7	7.1	13.2	17.0
Nov. 12,	10.6	4.5	15.5	9.6
Dec. 10,	10.8	6.5	15.6	–

MALDEN.

WATER SUPPLY OF MALDEN, MEDFORD AND MELROSE.

During the spring of 1892 Spot Pond failed to fill, the highest point reached being about four feet below high-water mark. In consequence of this failure, and on account of the large draft from the pond during the remaining months of the year, it has been drawn to a much lower level than ever before, the lowest point reached during the year being a little more than eleven feet below high-water mark. This draft diminishes the size of the pond to less than half its original area.

Chemical Examination of Water from Spot Pond, Stoneham.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8403	Jan. 6	Jan. 7	Slight, clayey.	Slight.	0.18	4.15	1.50	.0000	.0170	.0144	.0026	.45	.0050	.0000	1.3
8487	Feb. 4	Feb. 6	Slight.	Slight.	0.15	4.55	1.25	.0008	.0172	.0140	.0032	.49	.0070	.0000	1.4
8582	Mar. 4	Mar. 7	V. slight.	Slight.	0.20	4.05	1.30	.0048	.0198	.0162	.0036	.54	.0100	.0001	1.7
8718	Apr. 5	Apr. 8	V. slight.	Slight.	0.20	4.15	1.10	.0014	.0166	.0124	.0042	.47	.0150	.0000	1.6
8861	May 5	May 6	Slight.	Slight.	0.15	3.60	0.95	.0008	.0184	.0156	.0028	.49	.0090	.0000	1.4
8974	June 6	June 7	Slight.	Slight.	0.20	4.05	1.30	.0002	.0180	.0142	.0038	.51	.0000	.0000	1.6
9077	July 7	July 9	Slight.	Slight.	0.15	4.05	1.35	.0002	.0186	.0148	.0038	.46	.0000	.0000	1.3
9198	Aug. 2	Aug. 3	Distinct.	Slight.	0.15	4.05	1.15	.0028	.0198	.0178	.0020	.52	.0000	.0000	1.7
9342	Sept. 1	Sept. 3	Distinct, green.	Slight.	0.12	4.25	1.35	.0000	.0190	.0146	.0044	.54	.0070	.0000	1.7
9501	Oct. 5	Oct. 7	Distinct.	Cons., yellow.	0.30	4.35	1.35	.0136	.0236	.0188	.0048	.52	.0150	.0002	2.0
9649	Nov. 7	Nov. 9	Distinct.	Cons.	0.08	4.75	1.55	.0078	.0266	.0176	.0090	.50	.0090	.0004	2.3
9767	Dec. 5	Dec. 7	Distinct.	Cons., dirty.	0.20	5.35	1.45	.0100	.0230	.0176	.0054	.53	.0200	.0000	2.8
Av.	....	....	....	....	0.17	4.28	1.30	.0035	.0198	.0157	.0041	.50	.0081	.0001	1.7

Odor, sometimes none, generally vegetable, frequently unpleasant or disagreeable, becoming grassy and mouldy on heating. —— The samples were collected from a faucet at the pumping station of the Malden water works or from the pond near by.

MALDEN.

Microscopical Examination of Water from Spot Pond, Stoneham.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	8	8	10	9	6	8	8	4	3	8	10	8
Number of sample,	8403	8487	8582	8718	8861	8974	9077	9198	9342	9501	9649	9767
PLANTS.												
Diatomaceæ,	**422**	**388**	**143**	**207**	**2,107**	**274**	**42**	**52**	**133**	**12**	**82**	**205**
Asterionella,	42	136	36	78	1,816	26	4	9	61	0	0	2
Cyclotella,	134	196	60	40	136	108	5	2	2	3	14	8
Diatoma,	4	pr.	0	34	6	0	0	0	1	0	2	0
Fragilaria,	0	0	1	0	0	0	15	0	0	0	0	0
Melosira,	20	0	1	0	83	16	8	33	59	0	50	32
Navicula,	0	0	0	1	4	0	1	0	3	3	2	1
Striatella,	0	0	0	0	8	0	0	0	0	0	0	0
Synedra,	92	54	40	52	17	124	9	8	3	6	3	6
Tabellaria,	130	2	5	2	37	0	pr.	0	4	0	11	156
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**11**	**7**	**93**	**169**	**4**	**4**	**17**
Anabæna,	0	0	0	0	0	10	0	92	164	0	0	16
Chroöcoccus,	0	0	0	0	0	0	7	0	0	4	4	0
Clathrocystis,	0	0	0	0	0	1	pr.	1	5	0	0	1
Algæ,	**12**	**5**	**18**	**10**	**pr.**	**30**	**15**	**27**	**39**	**9**	**0**	**397**
Chlorococcus,	1	0	7	0	0	30	3	24	0	8	0	1
Conferva,	0	0	0	0	0	0	0	0	9	0	0	0
Dictyosphærium,	0	0	4	0	0	0	0	0	0	0	0	18
Protococcus,	0	0	0	0	5	0	0	0	12	0	0	60
Raphidium,	9	2	7	5	0	0	12	3	16	0	0	8
Staurastrum,	2	3	0	0	pr.	0	0	0	2	1	0	10
Tetraspora,	0	0	0	0	0	0	0	0	0	0	0	300
ANIMALS.												
Rhizopoda,	**1**	**pr.**	**0**	**1**	**0**	**1**	**0**	**0**	**5**	**0**	**0**	**2**
Actinophrys,	0	0	0	1	0	1	0	0	5	0	0	2
Difflugia,	1	pr.	0	0	0	0	0	0	0	0	0	0
Infusoria,	**2**	**2**	**2**	**5**	**9**	**0**	**49**	**56**	**24**	**4**	**7**	**16**
Dinobryon cases,	0	1	1	4	4	0	33	0	15	0	4	4
Glenodinium,	0	0	0	0	0	0	4	54	0	0	0	0
Monas,	0	1	0	0	2	0	0	0	0	0	0	0
Peridinium,	2	0	1	1	3	0	12	1	8	0	0	7
Trachelomonas,	pr.	pr.	0	0	pr.	0	pr.	1	1	4	3	5
Vermes,	**0**	**pr.**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**0**	**0**	**0**
Anurea,	0	pr.	0	0	0	0	1	1	1	0	0	0
Polyarthra,	0	0	0	0	0	1	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	**130**	**28**	**100**	**9**	**4**	**0**	**46**	**102**	**168**	**340**	**712**	**0**
TOTAL,	567	423	263	232	2,120	317	160	331	539	369	805	637

MALDEN.

Table showing Heights of Water in Spot Pond at the Times when Samples of Water were collected for Analysis.

DATE.	Distance below High-water Mark. Feet.	DATE.	Distance below High-water Mark. Feet.
1892.		**1892** — Con.	
Jan. 6,	6.3	July 7,	5.6
Feb. 4,	5.1	Aug. 2,	7.2
March 4,	5.2	Sept. 1,	8.2
April 5,	4.0	Oct. 5,	9.6
May 5,	4.7	Nov. 7,	11.0
June 6,	4.6	Dec. 5,	10.6

Water Supply of Malden.

The water commissioners of Malden, in July, 1892, asked the advice of the State Board of Health with reference to the propriety of taking the water of Martin's Pond in North Reading as a source of water supply, and the reply of the Board may be found on page 29 of this report. For analyses of the water of Martin's Pond and its principal tributary, see *North Reading*.

Chemical Examination of Water from Tubular Wells at Webster Park (Eaton's Meadows), Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8402	Jan. 6	Jan. 7	None.	None.	0.00	21.60	.0000	.0012	2.22	.4750	.0000	10.5	-
8488	Feb. 4	Feb. 6	None.	None.	0.00	22.80	.0000	.0002	2.42	.5500	.0001	12.0	-
8583	Mar. 4	Mar. 7	None.	V. slight.	0.00	23.60	.0000	.0002	2.38	.5000	.0000	12.0	-
8719	Apr. 5	Apr. 8	None.	None.	0.00	24.00	.0000	.0000	2.20	.5300	.0000	12.1	-
8862	May 5	May 6	V. slight.	None.	0.00	23.90	.0000	.0004	2.34	.5500	.0000	12.1	-
8975	June 6	June 7	None.	None.	0.00	24.00	.0000	.0004	2.73	.5000	.0000	11.6	-
9078	July 7	July 9	None.	None.	0.00	26.25	.0000	.0016	2.80	.5000	.0001	12.6	-
9197	Aug. 2	Aug. 3	None.	None.	0.00	24.35	.0000	.0008	2.73	.5000	.0000	11.8	-
9343	Sept. 1	Sept. 3	None.	Slight.	0.00	21.35	.0000	.0000	2.16	.5000	.0000	9.0	.0150
9502	Oct. 5	Oct. 7	Slight.	Slight, rusty.	0.05	20.75	.0000	.0000	1.98	.5500	.0000	10.7	.1050
9648	Nov. 7	Nov. 9	None.	V. slight.	0.01	21.30	.0000	.0016	2.25	.5000	.0000	10.8	.0090
9968	Dec. 5	Dec. 7	None.	None.	0.00	22.10	.0000	.0000	2.12	.5000	.0001	12.1	.0050
Av.	....	....	....	....	0.00	23.00	.0000	.0005	2.36	.5129	.0000	11.4	.0335

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Twenty-four two and one-half inch tubular wells were added to this source in 1892, the wells being all connected with the pumps on Aug. 30, 1892.

Microscopical Examination.

This water was practically free from organisms throughout the year, except in October and November, when the following numbers were found: October: Fungi, *Crenothrix*, 2,608; November: *Zoöglœa*, 26.

Water Supply of Manchester.

Description of Works. — Population in 1890, 1,789. The works are owned by the town. Water was introduced in February, 1892. The source of supply is a large well, with five tubular wells driven in its bottom, located in the valley of Saw-mill Brook a short distance north-east of the village and just above the point where it is joined by Brickyard Brook. The diameter of the well at the top is 33 feet, and at the bottom 31 feet; its depth is 29 feet. The tubular wells are each two and one-half inches in diameter and 24 feet deep, their lower ends being 27.5 feet below the mean level of the sea, from which they are distant about 3,500 feet, following the course of Saw-mill Brook. Water is pumped from the well to the town and to an iron tank 35 feet in diameter and 75 feet in height. Distributing mains are of cast iron; service pipes are of wrought iron lined with cement.

Chemical Examination of Water from a Well of the Manchester Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.		
	1892.												
8558	Feb. 29	Mar. 1	V. slight, clayey.	Slight.	0.00	7.80	.0000	.0002	1.78	.1100	.0001	3.51	-
8679	Mar. —	Mar. 29	V. slight, clayey.	V. slight.	0.00	8.65	.0002	.0006	1.56	.1500	.0002	2.99	-
8842	May 2	May 4	None.	V. slight.	0.00	8.75	.0000	.0000	1.63	.1500	.0000	2.86	-
8948	May 27	May 30	None.	V. slight.	0.00	10.30	.0000	.0006	1.81	.1500	.0001	3.00	-
9151	July 27	July 27	V. slight.	Slight.	0.00	10.90	.0002	.0000	1.88	.1000	.0001	3.90	-
9431	Sept. 23	Sept. 24	V. slight.	V. slight.	0.00	9.90	.0000	.0004	1.80	.0900	.0000	3.40	.0025
9805	Dec. 17	Dec. 17	None.	None.	0.02	9.35	.0000	.0002	1.78	.1000	.0000	3.90	.0040
Av.	....	....	....	....	0.00	9.38	.0001	.0003	1.75	.1214	.0001	3.37	-

Odor, none.—— The samples were collected from the well.

Microscopical Examination.

At times there is an insignificant number of organisms in this water, but generally none.

MANSFIELD.

Water Supply of Mansfield Water Supply District, Mansfield.

Chemical Examination of Water from the Well of the Mansfield Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8438	Jan. 20	Jan. 21	None.	None.	0.0	3.15	.0000	.0004	.23	.0100	.0000	0.6	–
8655	Mar. 23	Mar. 24	None.	None.	0.0	3.45	.0004	.0002	.28	.0090	.0000	0.8	–
8915	May 18	May 19	None.	None.	0.0	2.50	.0000	.0000	.28	.0170	.0000	0.8	–
Av.	....	....	....	....	0.0	3.03	.0001	.0002	.26	.0120	.0000	0.7	–

Odor, none. —— The first two samples were collected from a faucet at the pumping station; the last from a faucet near the centre of the town.

Microscopical Examination.

Only an insignificant number of organisms were found in this water.

Water Supply of Marblehead.

Chemical Examination of Water from the Wells of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8461	Jan. 28	Jan. 29	None.	None.	0.00	16.40	.0000	.0004	2.62	.5000	.0001	7.9	–
8505	Feb. 11	Feb. 11	None.	None.	0.00	14.00	.0000	.0012	2.20	.5000	.0000	6.3	–
8607	Mar. 10	Mar. 11	None.	None.	0.00	12.90	.0000	.0012	1.61	.2200	.0000	5.6	–
8869	May 7	May 10	None.	None.	0.00	19.60	.0000	.0000	4.22	.1500	.0000	8.1	–
8896	May 16	May 17	None.	None.	0.00	23.30	.0002	.0000	5.89	.2400	.0000	9.7	–
8987	June 10	June 10	None.	None.	0.00	31.40	.0006	.0006	8.73	.0750	.0000	11.5	–
9101	July 13	July 14	None.	None.	0.00	46.10	.0000	.0000	13.50	.1000	.0000	15.9	–
9224	Aug. 9	Aug. 10	Distinct, clayey.	V. slight.	0.02	65.95	.0000	.0020	23.60	.1000	.0015	20.4	.0500
9392	Sept. 19	Sept. 20	Slight, milky.	None.	0.02	24.65	.0000	.0000	6.90	.0650	.0001	8.7	.0300
9535	Oct. 15	Oct. 17	None.	None.	0.01	30.60	.0000	.0004	8.81	.0700	.0002	12.5	.0110
9668	Nov. 14	Nov. 15	None.	None.	0.00	70.85	.0000	.0000	26.41	.0600	.0000	15.1	.0140
9823	Dec. 20	Dec. 21	Distinct, clayey.	Slight.	0.02	32.90	.0006	.0000	10.20	.1500	.0000	13.6	.0250
Av.	....	....	....	....	0.01	32.39	.0001	.0005	9.56	.1808	.0002	11.3	.0260

Odor, none. —— The samples were collected from a faucet in the town, and represent a mixture of water drawn from the large well and the tubular wells.

Microscopical Examination.

In all of the samples except the last two the number of organisms did not in any case exceed 5 per cubic centimeter. The record for the last two samples is as follows: No. 9668, Miscellaneous, *Zoōglœa*, 52; No. 9823, *Zoōglœa*, 58.

MARBLEHEAD.

Chemical Examination of Water from Tubular Test Wells, Marblehead.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8397	Jan. 5	Jan. 6	Distinct, clayey.	None.	*0.0	13.40	.0010	.0000	1.66	.0050	.0000	6.29	.3368
9437	Sept. 25	Sept. 26	Distinct, milky.	Slight, rusty.	0.7	11.60	.0102	.0018	1.44	.0120	.0000	5.60	.2450

Odor of the first sample, none; of the last, disagreeable; disappearing on heating.—— These wells were driven with a view to obtaining an additional water supply from a small water-shed south-east of the present sources. The first sample was collected from a single tubular well located near a small pond about one thousand feet south-east of the pumping station, and the second sample from a group of six tubular wells in the same locality.

* After standing twenty-four hours the color was 0.5.

Microscopical Examination.

No. 8397. No organisms. No. 9437. Miscellaneous, *Zoöglœa*, very abundant.

Water Supply of Marlborough.

Works for an additional supply of water for Marlborough were begun in 1892, and were far advanced toward completion at the end of the year. The new source is Millham Brook, at the head of which the present source, Lake Williams, is situated. This brook enters the Assabet River from the west, and a short distance from the river it is joined by a northerly branch which is nearly as large as the main brook. The final plans contemplate the construction of a large storage reservoir by means of a dam across the brook, a short distance below the confluence of the main stream and the north branch, but for the present it is proposed to take water from the main brook above the north branch, on account of the better quality of the water. A small reservoir has been provided on this branch, from which water will be pumped for the supply of the city. The advice of the State Board of Health to the city of Marlborough with regard to an additional source of water supply may be found on page 30 of this volume. The analyses of water from the sources investigated will be found in tables which follow.

MARLBOROUGH.

Chemical Examination of Water from Lake Williams, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8620	Mar. 15	Mar. 16	Distinct, green	Slight.	0.10	4.20	1.45	.0016	.0242	.0184	.0058	.45	.0200	.0005	1.7
8723	Apr. 8	Apr. 9	Slight.	Slight.	0.05	4.40	1.50	.0000	.0246	.0164	.0082	.47	.0030	.0001	1.7

Odor of the first sample, faintly vegetable; of the second, vegetable and somewhat unpleasant, becoming disagreeable on heating. —— The samples were collected from the lake.

Microscopical Examination.

No. 8620. Diatomaceæ, *Asterionella*, 1; *Synedra*, 6; *Tabellaria*, 2. Infusoria, *Dinobryon*, 3; *Dinobryon cases*, 1; *Peridinium*, 22; *Gonium*, 2. Miscellaneous, *Zoöglœa*, 9. Total, 46.

No. 8723. Diatomaceæ, *Asterionella*, 24; *Cyclotella*, 1; *Cymbella*, 3; *Diatoma*, 1; *Fragilaria*, 9; *Navicula*, 2; *Stephanodiscus*, 1; *Synedra*, 104; *Tabellaria*, 43. Infusoria, *Dinobryon*, 9; *Dinobryon cases*, 10. Miscellaneous, *Zoöglœa*, 9. Total, 216.

Chemical Examination of Water from Millham Brook, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8618	Mar. 15	Mar. 16	None.	Slight.	0.50	4.35	1.55	.0000	.0160	.0138	.0022	.32	.0400	.0000	1.6
8674	Mar. 26	Mar. 28	Slight.	Cons., earthy.	0.35	2.90	1.35	.0010	.0186	.0156	.0030	.24	.0250	.0000	1.3
8675	Mar. 26	Mar. 28	V. slight.	Cons.	0.70	4.20	1.70	.0000	.0174	.0152	.0022	.22	.0100	.0000	1.6
9019	June 16	June 18	V. slight.	V. slight.	0.45	5.50	1.00	.0108	.0160	.0132	.0028	.36	.0100	.0004	1.9
Av.	....	....	....	....	0.50	4.24	1.40	.0029	.0170	.0144	.0026	.28	.0212	.0001	1.6

Odor of the first sample, none; of the next two, faintly vegetable; and of the last, distinctly vegetable and unpleasant. On heating, the odors were the same, except that in the second sample a vegetable and mouldy odor was developed.——No. 8618 was collected from the brook below the mouth of the north branch; Nos. 8674 and 9019 from the brook above the mouth of the north branch; No. 8675 from the north branch. These samples were collected during an investigation for an additional water supply for Marlborough.

Microscopical Examination.

The number of organisms in these samples ranged from 12 to 439, and averaged 141 per cubic centimeter.

MARLBOROUGH.

Chemical Examination of Water from Fort Meadow Reservoir, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8619	Mar. 15	Mar. 16	V. slight.	Slight.	0.10	2.95	1.30	.0008	.0200	.0144	.0056	.34	.0180	.0000	0.6
8721	Apr. 8	Apr. 9	Slight.	Cons., green.	0.08	3.25	1.25	.0000	.0216	.0160	.0056	.32	.0100	.0000	0.6
8722	Apr. 8	Apr. 9	Slight.	Cons., green.	0.10	3.40	1.35	.0000	.0226	.0136	.0090	.32	.0200	.0000	0.6
9020	June 16	June 18	V. slight.	Slight.	0.10	3.60	0.95	.0014	.0220	.0156	.0064	.38	.0030	.0001	0.6
9384	Sept. 15	Sept. 16	Distinct.	Cons., green.	0.10	3.15	1.40	.0000	.0276	.0176	.0100	.27	.0090	.0000	0.5
Av.	....	....	....	....	0.10	3.25	1.25	.0005	.0229	.0156	.0073	.33	.0112	.0000	0.6

Odor of the first and last samples, none; of the others, vegetable, and of those collected in April, also unpleasant —— The samples were collected from the reservoir near the lower end, excepting Nos. 8722 and 9020, which were collected from the causeway near the upper end. The samples were collected during an investigation for an additional water supply for Marlborough.

Microscopical Examination of Water from Fort Meadow Reservoir, Marlborough.

[Number of organisms per cubic centimeter.]

	1892. March.	1892. April.	1892. April.	1892. June.	1892. September.
Day of examination,	17	11	11	22	17
Number of sample,	8619	8721	8722	9020	9384
PLANTS.					
Diatomaceæ,	**627**	**838**	**403**	**427**	**640**
Asterionella,	42	180	124	24	8
Cyclotella,	1	98	15	11	112
Diatoma,	0	0	0	3	58
Fragilaria,	6	0	0	2	7
Melosira,	2	4	23	13	80
Navicula,	0	0	2	pr.	7
Synedra,	544	544	220	82	88
Tabellaria,	32	12	19	292	280
Cyanophyceæ,	**0**	**10**	**3**	**12**	**56**
Chroöcoccus,	0	8	2	2	4
Microcystis,	0	2	1	5	52
Nostoc spores,	0	0	0	5	0
Algæ,	**449**	**47**	**26**	**6**	**228**
Chlorococcus,	0	23	9	0	0
Hyalotheca,	4	20	0	0	0
Protococcus,	0	pr.	1	2	30
Raphidium,	1	0	0	2	112
Scenedesmus,	pr.	0	1	1	21
Selenastrum,	0	0	0	0	55
Staurastrum,	2	2	3	1	4
Staurogenia,	pr.	pr.	0	0	5
Tetraspora,	2	pr.	7	0	1
Tetraspora cells,	434	0	0	0	0
Zoöspores,	6	2	5	0	0
Fungi. Molds,	**0**	**0**	**0**	**0**	**3**

MARLBOROUGH.

Microscopical Examination of Water from Fort Meadow Reservoir, Marlborough — Concluded.

[Number of organisms per cubic centimeter.]

	1892.				
	March.	April.	April.	June.	September.
ANIMALS.					
Infusoria,	**32**	**84**	**133**	**pr.**	**5**
Cryptomonas,	18	7	1	0	0
Dinobryon,	14	72	5	0	0
Dinobryon cases,	0	1	124	0	0
Peridinium,	0	0	2	pr.	0
Trachelomonas,	0	4	1	0	5
Vermes,	**1**	**pr.**	**2**	**1**	**0**
Anurea,	1	pr.	0	0	0
Monocerca,	0	0	0	1	0
Polyarthra,	0	0	2	0	0
Miscellaneous. Zoöglœa,	34	100	40	300	112
TOTAL,	1,143	1,079	607	756	1,116

WATER SUPPLY OF MAYNARD.

Chemical Examination of Water from the Maynard Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved	Ammonia. Albuminoid. Suspended	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8420	Jan. 13	Jan. 14	V. slight	V. slight	0.00	2.65	1.55	.0000	.0068	.0060	.0008	.22	.0050	.0000	0.3
8799	Apr. 25	Apr. 26	V. slight.	Slight.	0.00	2.00	0.90	.0000	.0210	.0174	.0036	.25	.0020	.0000	0.5
9143	July 26	July 26	V. slight.	V. slight.	0.03	2.55	0.25	.0002	.0070	.0058	.0012	.23	.0000	.0000	1.3
9561	Oct. 24	Oct. 25	V. slight.	Slight, white.	0.02	1.85	0.75	.0000	.0198	.0156	.0042	.23	.0050	.0000	0.5
Av.	....	....	....	....	0.01	2.26	0.86	.0000	.0136	.0112	.0024	.23	.0030	.0000	0.6

Odor of the first sample, vegetable; of all others, none. No. 9143 developed a disagreeable odor on standing twenty-four hours. — The first and third samples were collected from a faucet in the village; the others, from White Pond. The difference between the analyses of samples collected in the village and from the pond indicates that a large amount of ground water finds its way into the pipe leading from the pond to the pumping station.

MAYNARD.

Microscopical Examination of Water from the Maynard Water Works.

[Number of organisms per cubic centimeter.]

	1892.			
	January.	April.	July.	October.
Day of examination,	15	28	27	25
Number of sample,	8420	8799	9143	9561
PLANTS.				
Diatomaceæ,	**1,028**	**363**	**14**	**51**
Asterionella,	784	65	pr.	14
Cyclotella,	0	3	0	4
Melosira,	0	5	0	0
Synedra,	48	82	1	13
Tabellaria,	196	208	13	20
Cyanophyceæ,	**0**	**0**	**0**	**118**
Chroöcoccus,	0	0	0	12
Microcystis,	0	0	0	106
Algæ,	**7**	**11**	**pr.**	**5**
Chlorococcus,	4	0	0	0
Hyalotheca,	2	10	0	0
Raphidium,	1	0	0	4
Scenedesmus,	0	1	pr.	0
Staurastrum,	0	0	0	1
ANIMALS.				
Infusoria,	**1**	**21**	**0**	**48**
Dinobryon,	0	0	0	9
Dinobryon cases,	1	20	0	38
Peridinium,	0	1	0	1
Encysted Protozoön,	0	0	0	pr.
Vermes,	**0**	**0**	**0**	**pr.**
Monocerca,	0	0	0	pr.
Polyarthra,	0	0	0	pr.
Miscellaneous. Zoögloea,	**9**	**0**	**0**	**76**
Total,	1,045	395	14	298

MEDFIELD.

Medfield.

Chemical Examination of Water from a Spring, Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.											
8514	Feb. 15	Feb. 17	None.	None.	0.0	3.65	.0000	.0008	.33	.0850	.0000	1.11

Odor, none. —— The sample was collected from a spring near Vine Brook, about a third of a mile above North Street. This spring, at the time of collecting the sample, was connected by means of an eight-inch vitrified pipe with a pump operated by a windmill and also with a steam pump in the straw factory in the village, and the water was used for the supply of the factory and a portion of the village. The water was examined with reference to obtaining a water supply for the town from the ground in the vicinity of the spring, and the Board subsequently approved this source as an appropriate one for a water supply for Medfield (see page 33).

Microscopical Examination.

No organisms.

Chemical Examination of Water from Tubular Test Wells at the Medfield Insane Asylum, Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9298	Aug. 24	Aug. 25	Slight.	Cons., sand.	0.0	3.30	.0000	.0000	.22	,0000	.0000	1.4	.0800
9370	Sept. 13	Sept. 14	None.	None.	0.0	2.85	.0004	.0002	.21	.0070	.0000	0.8	.0075

Odor, none. —— The samples were collected from two two and one-half inch test wells near Charles River. The first well is twenty-eight feet deep and seventy-five feet from the river; the second is twenty-four feet deep and fifty feet from the river. The samples were collected during an investigation for a water supply for the Medfield Insane Asylum, and the advice of the Board with regard thereto may be found on page 33 of this volume.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Charles River at Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9313	Aug.26	Aug.27	V.slight.	V.slight.	0.80	5.45	1.90	.0004	.0244	.0216	.0028	.36	.0070	.0002	1.8

The sample was collected from the river, near the boundary line between Dover and Medfield, and near the test wells above mentioned.

Water Supply of Medford.

(See *Malden.*)

Water Supply of Melrose.

(See *Malden.*)

Medway.

Chemical Examination of Water from Chicken Brook, Medway.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8504	Feb. 10	Feb. 11	V. slight.	V. slight.	0.65	3.90	1.30	.0000	.0138	.0122	.0016	.32	.0200	.0000	1.3

Odor, vegetable.——The sample was collected from the brook at the old box-mill dam, above Main Street, Medway, during an investigation for a water supply for Medway. The advice of the Board with regard to this source may be found on page 34 of this volume.

Microscopical Examination.

Diatomaceæ, *Meridion*, 2; *Synedra*, 5. Miscellaneous, *Zoöglœa*, 1. Total, 8.

Mendon.

Chemical Examination of Water from Mendon or Nipmuck Pond, Mendon.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9592	Oct. 29	Oct. 31	Slight.	Cons.	0.03	2.05	0.70	.0000	.0142	.0116	.0026	.20	.0030	.0000	0.3

Odor of the first sample, very faintly vegetable, becoming decidedly vegetable, disagreeable and oily on heating. —— The sample was collected from the pond at the surface at a place where the water was about eleven feet in depth. This sample was collected during an investigation for an additional supply of water for Uxbridge, and the advice of the Board with regard to this source may be found on page 46 of this volume.

Microscopical Examination.

Diatomaceæ, *Navicula*, 1; *Synedra*, 12. Cyanophyceæ, *Anabæna*, 2; *Chroöcoccus*, 32; *Microcystis*, 2. Algæ, *Chlorococcus*, 536; *Closterium*, 13; *Conferva*, 84; *Staurastrum*, 4. Infusoria, *Cryptomonas*, 2; *Dinobryon cases*, 1; *Monas*, 2; *Peridinium*, 2; *Uroglena*, 6. Vermes, *Anurea*, 1; *Rotatorian ova*, 1. Miscellaneous, *Zoöglœa*, 60. Total, 761.

MILFORD.

Water Supply of Milford and Hopedale. — Milford Water Company.

Chemical Examination of Water from one of the Wells of the Milford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.											
9225	Aug. 10	Aug. 11	Slight.	Slight.	0.25	4.50	.0010	.0138	.26	.0180	.0001	1.7

Odor, vegetable. —— The sample was collected from one of the large wells on the right bank of the Charles River, above Milford, and was wholly or in part river water.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 8; *Melosira*, 8; *Navicula*, 10; *Synedra*, 9. Algæ, *Scenedesmus*, 1; *Staurastrum*, 2. Fungi, *Crenothrix*, 132. Infusoria, *Dinobryon cases*, 8. Crustacea, *Cyclops*, .02. Miscellaneous, *Zoöglœa*, 120. Total, 298.

Water Supply of Millis. — Millis Water Company.

Chemical Examination of Water from the Aqua Rex Spring, Millis.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.											
8499	Feb. 10	Feb. 11	None.	None.	0.0	5.60	.0000	.0014	.38	.1750	.0000	1.9

Odor, none. —— The sample was collected directly from the spring.

Microscopical Examination.

No organisms.

MILTON.

WATER SUPPLY OF MILTON. — MILTON WATER COMPANY.

The water supplied by this company to the town is purchased from the Hyde Park Water Company, and a statement with regard to the supply and analyses of the water may be found on pages 142 to 146. The advice of the State Board of Health to the school committee of Hyde Park and to the water committee of the town of Milton with regard to the quality of this water may be found on pages 14 and 35.

WATER SUPPLY OF NAHANT.

(See *Swampscott.*)

WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

Chemical Examination of Water from Wannacomet Pond, Nantucket.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8868	May 5	May 7	Slight.	Cons.	0.00	6.90	2.25	.0000	.0122	.0084	.0038	2.03	.0200	.0000	1.6
8976	June 6	June 8	Slight.	Slight.	0.00	7.30	2.30	.0006	.0164	.0144	.0020	2.38	.0000	.0000	1.2
9025	June21	June22	Slight.	Cons.	0.04	7.95	2.65	.0000	.0150	.0114	.0036	2.38	.0000	.0000	1.4
9075	July 6	July 7	Slight.	Slight.	0.02	6.55	1.35	.0004	.0156	.0134	.0022	2.38	.0000	.0000	1.4
9123	July 18	July 20	Slight.	Cons.	0.05	6.60	1.60	.0006	.0154	.0130	.0024	2.22	.0000	.0000	2.1
9160	July 27	July 28	V. slight.	Cons.	0.03	6.25	0.90	.0000	.0166	.0142	.0024	2.10	.0000	.0001	1.7
9194	Aug. 2	Aug 3	Distinct.	Slight.	0.08	6.75	1.75	.0014	.0140	.0122	.0018	2.18	.0000	.0000	2.0
9331	Aug.31	Sept. 2	Slight.	Cons.	0.02	6.75	1.40	.0000	.0136	.0106	.0030	2.24	.0000	.0002	1.7
9434	Sept.23	Sept 26	V. slight.	Slight.	0.05	6.20	0.95	.0006	.0130	.0108	.0022	2.40	.0000	.0000	1.5
9541	Oct. 17	Oct. 19	Slight.	Cons.	0.02	6.85	1.15	.0000	.0104	.0084	.0020	2.17	.0000	.0000	1.7
Av.	....	....	....	....	0.03	6.84	1.68	.0004	.0136	.0111	.0025	2.22	.0033	.0000	1.6

Odor of Nos. 9025, 9075, 9160 and 9194, vegetable, and in the last sample, disagreeable; of all others, none. —— The samples were collected from the pond, six inches beneath the surface, excepting No. 9025, which was collected eighteen feet beneath the surface.

NOTE. — This pond was affected in 1891 by an abundant growth of *Anabæna*, as noted in the last annual report of the State Board of Health, page 178. At that time, owing to the presence of this minute vegetable organism, the amount of albuminoid ammonia was in one sample .0920 parts per 100,000, while the largest amount in 1892, when the *Anabæna* was absent, was, as shown in the above table, .0166 parts.

NANTUCKET.

Microscopical Examination of Water from Wannacomet Pond, Nantucket.

[Number of organisms per cubic centimeter.]

	1892.									
	May.	June.	June.	July.	July.	July.	Aug.	Sept.	Sept.	Oct.
Day of examination,	7	9	22	7	20	28	3	2	27	20
Number of sample,	8868	8976	9025	9075	9123	9160	9194	9331	9434	9541
PLANTS.										
Diatomaceæ,	**78**	**442**	**15**	**1**	**7**	**61**	**46**	**pr.**	**pr.**	**3**
Cyclotella,	64	6	3	pr.	0	0	0	0	0	pr.
Fragilaria,	0	9	0	0	0	0	2	0	0	0
Melosira,	0	1	0	0	0	52	0	0	0	0
Navicula,	12	4	2	1	5	9	pr.	pr.	pr.	2
Synedra,	2	422	10	pr.	2	pr.	44	pr.	0	1
Cyanophyceæ,	**0**	**0**	**22**	**0**	**2**	**0**	**134**	**18**	**1**	**0**
Chroöcoccus,	0	0	20	0	0	0	134	0	0	0
Clathrocystis,	0	0	2	0	2	0	0	18	1	0
Algæ,	**15**	**246**	**68**	**19**	**1**	**0**	**3**	**0**	**pr.**	**0**
Chlorococcus,	3	224	43	13	0	0	0	0	0	0
Cosmarium,	2	1	1	1	0	0	pr.	0	0	0
Protococcus,	0	6	23	0	0	0	0	0	0	0
Scenedesmus,	3	15	1	pr.	0	0	2	0	0	0
Staurastrum,	7	0	0	5	1	0	1	0	pr.	pr.
ANIMALS.										
Infusoria,	**484**	**6**	**372**	**4**	**1**	**1**	**10**	**1,683**	**65**	**0**
Ceratium,	0	0	0	pr.	1	1	4	0	0	0
Dinobryon,	9	0	0	0	0	0	0	542	0	0
Dinobryon cases,	482	6	372	4	0	0	0	1,140	64	0
Monas,	0	pr.	0	0	0	0	0	0	1	0
Peridinium,	2	pr.	0	pr.	0	0	4	1	0	0
Peridinium cases,	0	0	0	0	0	0	2	0	0	0
Trachelomonas,	0	pr.	0	0	0	pr.	pr.	pr.	pr.	0
Vermes,	**pr.**	**0**	**1**	**2**	**1**	**0**	**0**	**0**	**0**	**0**
Anurea,	pr.	0	0	1	0	0	0	0	0	0
Monocerca,	0	0	1	0	0	0	0	0	0	0
Polyarthra,	pr.	0	0	1	1	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	**40**	**156**	**76**	**46**	**100**	**47**	**13**	**158**	**pr.**	**68**
TOTAL,	617	850	554	72	112	109	206	1,859	66	71

NANTUCKET.

Chemical Examination of Water from Gibbs Pond, and from the North Head of Hummock Pond, Nantucket.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9435	Sept.23	Sept.26	Slight.	Slight.	0.50	6.00	1.95	.0000	.0162	.0134	.0028	2.40	.0000	.0002	0.9
9436	Sept.23	Sept.26	Decided.	Cons., yellow.	0.10	9.70	2.10	.0056	.0492	.0220	.0272	2.80	.0030	.0002	3.1

Odor of the first sample, faintly vegetable; of the last, distinctly mouldy and disagreeable. —— The first sample was collected from Gibbs Pond, thirty feet from shore, where water was two feet deep. The second sample was collected from the north head of Hummock Pond, opposite the ice house, twenty-five feet from shore. These samples were collected during an investigation for a new water supply for the town of Nantucket. The advice of the State Board of Health, as contained in a reply to a town committee on water supply, may be found on page 36 of this volume.

Water Supply of Natick.

Chemical Examination of Water from Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of: Collection.	Date of: Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8381	Jan. 4	Jan. 5	Slight.	Slight.	0.10	5.35	1.00	.0180	.0204	.0156	.0048	.70	.0200	.0002	2.0
8479	Feb. 2	Feb. 2	V.slight.	V.slight.	0.10	5.05	1.65	.0134	.0178	.0148	.0030	.76	.0550	.0001	2.3
8580	Mar. 3	Mar. 4	Milky	Cons.	0.07	5.50	1.20	.0132	.0160	.0144	.0016	.76	.0680	.0005	3.1
8707	Apr. 4	Apr. 5	Slight.	V.slight.	0.08	5.25	1.05	.0124	.0210	.0132	.0078	.68	.0400	.0001	2.0
8843	May 3	May 4	Slight.	Slight.	0.05	5.50	1.05	.0026	.0178	.0162	.0016	.70	.0600	.0000	2.3
8960	June 1	June 2	V.slight.	V.slight.	0.03	5.55	1.05	.0024	.0126	.0108	.0018	.74	.0500	.0001	2.2
9073	July 5	July 7	V.slight.	V.slight	0.05	5.60	1.15	.0022	.0144	.0122	.0022	.72	.0380	.0001	2.3
9196	Aug. 3	Aug. 3	Slight.	Slight.	0.10	5.60	1.35	.0022	.0164	.0142	.0022	.74	.0200	.0003	2.9
9330	Sept. 1	Sept. 2	Decided, green.	Slight, green.	0.05	5.25	1.40	.0000	.0222	.0142	.0080	.73	.0050	.0003	2.2
9495	Oct. 4	Oct. 5	Slight.	Slight.	0.05	5.20	1.65	.0000	.0196	.0142	.0054	.66	.0070	.0000	2.2
9620	Nov. 3	Nov. 4	Slight	Slight, green.	0.02	5.25	1.20	.0122	.0172	.0126	.0046	.70	.0100	.0001	2.5
9759	Dec. 5	Dec. 6	V.slight.	V.slight	0.08	5.45	1.10	.0030	.0130	.0100	.0030	.71	.0150	.0000	2.3
Av.	....	....	....	....	0.06	5.38	1.24	.0068	.0173	.0135	.0038	.72	.0323	.0001	2.4

Odor, vegetable and frequently mouldy or unpleasant; on heating, the odor is generally stronger. —— The samples were collected from a faucet at the pumping station. For heights of water in the pond at times when samples of water were collected for analysis, see page 191.

NOTE. — Many dead fish came ashore in the last of May. A similar condition was noted in June, 1891.

NATICK.

Microscopical Examination of Water from Dug Pond, Natick.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	3	9	6	5	2	6	4	2	5	8	6
Number of sample,	8381	8479	8580	8707	8843	8960	9073	9196	9330	9495	9620	9759
PLANTS.												
Diatomaceæ,	**991**	**199**	**97**	**321**	**284**	**16**	**71**	**12**	**144**	**85**	**661**	**263**
Asterionella,	150	76	22	66	5	0	0	0	0	7	76	54
Cyclotella,	86	0	25	70	218	11	50	0	0	2	48	92
Diatoma,	3	56	0	5	0	0	8	0	0	0	0	0
Fragilaria,	0	4	3	0	pr.	0	0	0	4	0	0	0
Melosira,	676	1	2	98	22	1	0	11	132	76	536	112
Synedra,	46	62	44	70	34	1	0	1	8	0	1	2
Tabellaria,	30	0	1	12	5	3	13	0	0	0	0	3
Cyanophyceæ,	**14**	**0**	**0**	**2**	**17**	**0**	**3**	**5**	**113**	**115**	**pr.**	**pr.**
Aphanocapsa,	pr.	0	0	0	0	0	0	1	48	1	pr.	0
Chroöcoccus,	13	0	0	2	17	0	0	3	0	0	0	0
Clathrocystis,	pr.	0	0	0	0	0	3	0	60	1	0	0
Homolococcus,	0	0	0	0	0	0	0	0	0	17	0	0
Microcystis,	1	0	0	0	0	0	0	1	5	96	0	pr.
Algæ,	**2**	**11**	**pr.**	**3**	**1**	**2**	**1**	**20**	**55**	**1**	**1**	**1**
Botrycoccus,	0	0	0	0	0	0	pr.	0	7	0	0	0
Chlorococcus,	2	7	0	2	0	2	0	19	2	1	pr.	0
Protococcus,	0	0	0	0	0	pr.	pr.	0	44	0	0	0
Scenedesmus,	0	4	0	1	0	0	0	0	0	0	1	1
Sorastrum,	0	0	pr.	0	1	0	1	1	2	0	0	0
Fungi. Crenothrix,	**0**	**0**	**0**	**1**	**0**	**0**	**448**	**1**	**0**	**10**	**20**	**0**
ANIMALS.												
Rhizopoda,	**1**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**
Actinophrys,	1	0	0	0	0	0	0	0	0	1	0	0
Difflugia,	0	0	0	4	0	0	0	0	0	1	0	0
Infusoria,	**3**	**0**	**3**	**21**	**6**	**0**	**0**	**0**	**14**	**4**	**118**	**pr.**
Dinobryon,	0	0	0	0	1	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	5	0	0	0	13	0	118	0
Euglena,	1	0	0	0	0	0	0	0	0	0	0	0
Peridinium,	pr.	0	0	1	0	0	0	0	1	3	0	0
Podophrys,	6	0	pr.	20	0	0	0	0	0	0	0	0
Synura,	pr.	0	3	0	0	0	0	0	0	0	0	0
Trachelomonas,	2	0	pr.	pr.	0	0	0	0	0	1	pr.	pr.
Miscellaneous. Zoöglœa,	**30**	**92**	**84**	**48**	**38**	**0**	**0**	**15**	**0**	**0**	**18**	**0**
TOTAL,	1,041	302	184	400	346	18	523	53	326	217	818	264

NATICK.

Chemical Examination of Water from Tubular Test Wells on the shore of Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9533	Oct. 14	Oct. 15	Distinct, clayey.	Heavy, sandy.	0.07	6.75	.0000	.0018	0.92	.0050	.0000	2.3	.0500
9534	Oct. 14	Oct. 15	Distinct.	Heavy, sandy.	0.02	9.40	.0014	.0024	1.16	.1700	.0020	3.5	.0650

Odor, none. —— The samples were collected from two tubular wells, numbered respectively 1 and 2, on the shore of Dug Pond.

Microscopical Examination.

No organisms.

Table Showing Heights of Water in Dug Pond at times when Samples of Water were collected for Analysis.

[Note. — Ordinary high-water mark is 13.0 feet.]

Date.	Height of Water.	Date.	Height of Water.
	Feet.		Feet.
Jan. 4,	10.5	July 5,	11.7
Feb. 2,	13.1	Aug. 3,	10.2
Mar. 3,	13.2	Sept. 1,	9.6
April 4,	13.4	Oct. 4,	8.8
May 3,	13.6	Nov. 3,	7.9
June 1,	13.0	Dec. 5,	8.5

Water Supply of Needham.

Chemical Examination of Water from the Well of the Needham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9102	July 13	July 14	None.	None.	0.0	5.90	.0000	.0002	.68	.1800	.0000	1.9	-
9223	Aug. 10	Aug. 10	None.	None.	0.0	6.35	.0000	.0000	.62	.1000	.0000	2.3	.0072

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

NEW BEDFORD.

Water Supply of New Bedford.

Chemical Examination of Water from the Conduit of the New Bedford Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8462	Jan. 28	Jan. 29	V. slight.	Slight.	1.25	5.90	2.50	.0008	.0256	.0230	.0026	.62	.0120	.0001	1.1
8554	Feb. 25	Feb. 26	V. slight.	V. slight.	1.40	5.85	2.90	.0026	.0230	.0206	.0024	.59	.0070	.0001	1.3
8676	Mar. 28	Mar. 28	V. slight.	Slight.	1.00	4.70	1.85	.0004	.0196	.0176	.0020	.48	.0120	.0000	1.1
8822	Apr. 28	Apr. 29	V. slight.	Cons., brown.	0.90	4.25	2.20	.0000	.0168	.0148	.0020	.50	.0090	.0000	0.6
8937	May 26	May 26	V. slight.	Slight.	1.30	4.90	2.00	.0002	.0222	.0182	.0040	.48	.0050	.0000	0.6
9043	June 29	June 30	Slight.	Slight, rusty.	1.70	5.00	2.85	.0000	.0296	.0236	.0060	.43	.0070	.0001	0.9
9147	July 27	July 27	V. slight.	Cons.	1.20	4.75	2.40	.0010	.0280	.0222	.0058	.43	.0100	.0001	0.8
9294	Aug. 24	Aug 24	Slight.	Cons., brown.	0.90	4.35	2.35	.0000	.0218	.0198	.0020	.48	.0070	.0000	1.7
9457	Sept. 28	Sept. 29	Slight.	Slight.	0.60	3.75	1.70	.0000	.0196	.0184	.0012	.53	.0090	.0001	0.9
9573	Oct. 26	Oct. 27	Slight.	Slight.	0.55	3.70	1.30	.0000	.0188	.0146	.0042	.49	.0090	.0000	0.7
9731	Nov. 28	Nov. 29	V. slight.	V. slight.	1.05	5.30	2.55	.0008	.0224	.0190	.0034	.60	.0100	.0001	1.4
9811	Dec. 20	Dec. 21	V. slight.	V. slight.	1.30	5.95	2.25	.0014	.0248	.0210	.0038	.58	.0200	.0001	1.4
Av.	....	....	....	....	1.10	4.87	2.24	.0006	.0227	.0194	.0033	.52	.0108	.0001	1.0

Odor, vegetable and sweetish, becoming less strong on heating; rarely none.—The samples were collected from the conduit at its entrance to the receiving reservoir. From Jan. 1 to June 16, 1892, no water was drawn from Little Quittacas Pond into the Acushnet Reservoir. On the latter date the connection was opened, and water flowed from Little Quittacas into the storage reservoir until Dec. 19, 1892, when the connection was again closed. For a record of the height of water in the pond and storage reservoir on the dates when samples of water were collected from the conduit for analysis, see page 193.

Microscopical Examination of Water from the Conduit of the New Bedford Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	30	26	29	30	26	30	28	25	29	27	30	21
Number of sample, . . .	8462	8554	8676	8822	8937	9043	9147	9294	9457	9573	9731	9811
PLANTS.												
Diatomaceæ, ...	**12**	**10**	**3**	**51**	**0**	**0**	**0**	**pr.**	**5**	**0**	**0**	**10**
Asterionella, ...	7	0	1	0	0	0	0	0	0	0	0	1
Diatoma, ...	0	0	0	5	0	0	0	pr.	0	0	0	4
Melosira, ...	1	0	0	0	0	0	0	0	4	0	0	3
Synedra, ...	4	10	2	46	0	pr.	6	pr.	1	0	0	2

NEW BEDFORD.

Microscopical Examination of Water from the Conduit of the New Bedford Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**28**	**103**	**120**	**2**	**0**	**0**	**0**
Chroöcoccus,	0	0	0	0	0	9	5	4	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	2	4	0	0	0	0
Merismopedia,	0	0	0	0	0	18	92	106	0	0	0	0
Microcystis,	0	0	0	0	0	1	4	6	2	0	0	0
Algæ,	**0**	**0**	**0**	**6**	**0**	**4**	**39**	**39**	**0**	**0**	**0**	**0**
Chlorococcus,	0	0	0	4	0	4	38	26	0	0	0	0
Raphidium,	0	0	0	2	0	0	1	13	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**pr.**	**2**	**15**	**62**	**1**	**4**	**0**	**pr.**	**pr.**	**3**
ANIMALS.												
Infusoria,	**9**	**3**	**5**	**11**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**
Dinobryon,	4	1	2	0	0	0	0	0	0	0	0	0
Dinobryon cases,	4	pr.	0	11	0	0	0	0	0	0	0	0
Peridinium,	1	2	3	0	0	0	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	**28**	**pr.**	**0**	**58**	**16**	**58**	**128**	**94**	**pr.**	**10**	**19**	**9**
TOTAL,	49	13	8	128	31	152	271	257	7	10	19	22

Table showing Heights of Water in Acushnet Reservoir and Little Quittacas Pond in 1892.

DATE.	Acushnet Reservoir. Distance below High-water Mark.	Little Quittacas Pond. Distance below High-water Mark.	DATE.	Acushnet Reservoir. Distance below High-water Mark.	Little Quittacas Pond. Distance below High-water Mark.
	Feet.	Feet.		Feet.	Feet.
Jan. 28,	0.0	2.2	July 27,	1.0	2.5
Feb. 25,	0.0	1.8	Aug. 24,	1.6	3.3
Mar. 28,	0.0	1.0	Sept. 28,	2.0	3.4
Apr. 28,	0.0	1.2	Oct. 26,	3.1	3.7
May 26,	0.0	1.0	Nov. 28,	2.2	3.3
June 29,	0.5	1.6	Dec. 20,	0.7	3.1

NEWBURYPORT.

Water Supply of Newburyport. — Newburyport Water Company.

In the latter part of 1892 the spring water sources of the Newburyport Water Company were inadequate to supply a sufficient amount of water for the city, and the company resorted to the Merrimack River opposite the pumping station as a source of additional water supply. The river at this point is affected by the tides, is more or less salt at times, and above this point receives the sewage of many cities and towns, including Lowell, Lawrence, Haverhill and Amesbury in Massachusetts. A communication from the State Board of Health to the Newburyport Water Company, with reference to the Merrimack River as a source of water supply, may be found on page 38 of this volume.

Chemical Examination of Water from the Wells and Reservoir of the Newburyport Water Company.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
9406	Sept. 20	Sept. 21	None.	None.	0.00	4.85	-	.0000	.0016	-	-	.41	.0280	.0000	2.1
9407	Sept. 20	Sept. 21	V. slight.	Slight.	0.08	5.25	1.10	.0000	.0112	.0088	.0024	.49	.0050	.0000	2.1
9408	Sept. 20	Sept. 21	V. slight.	V. slight.	0.10	5.80	1.20	.0000	.0068	.0044	.0024	.49	.0120	.0001	2.2

Odor of the first and last sample, none; of the second, very faintly vegetable. —— The first sample was collected from the wells, the second sample from the small storage reservoir near the pumping station, and the third sample from a faucet near the centre of the city.

Microscopical Examination.

No organisms were found in the first sample; the second and third contained respectively 104 and 26 organisms per cubic centimeter.

NEWBURYPORT.

Chemical Examination of Water from the Merrimack River opposite the Works of the Newburyport Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9412	Sept. 20	Sept. 21	-	-	-	-	-	-	-	-	-	14.30	-	-	-
9642	Nov. 7	Nov. 8	Slight.	Cons.	0.25	26.15	4.80	.0102	.0198	.0154	.0044	10.82	.0070	.0003	6.7

Odor of the last sample, distinctly musty.——The samples were collected from the river at the point where water is drawn from it by the Newburyport Water Company. The first sample was collected at 12.30 P.M., between one and two hours after high tide, during a course of average tides; the second sample was collected at 6.45 A.M., at about low tide, during a course of spring tides.

Microscopical Examination.

No. 9412. Not examined.

No. 9642. Diatomaceæ, *Gyrosigma*, 1; *Melosira*, 9; *Navicula*, 3. Algæ, *Chlorococcus*, 5. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 456. Total, 475.

Water Supply of Newton.

The last annual report of the Board contained a description of the extension of the works for obtaining a supply of ground water for Newton. The extension consisted of a long wooden conduit or filter-gallery, a portion of which, 732 feet in length, replaced an equal length of the original filter-basin. It was then contemplated to extend the gallery through the remaining portion of the filter-basin, but it was not thought advisable to do it at the time, so that all of the water collected in the gallery was exposed to the light while passing through the open portion of the filter-basin. In the summer of 1892 there was a very abundant plant growth in the open filter-basin, chiefly of the filamentous Alga, *Spirogyra*, which gave the water a disagreeable odor and caused much complaint from the consumers. Later in the season the filter-gallery was extended, replacing the remaining portion of the open filter-basin, so that the water is now delivered to the consumers without exposure to the light at any place. The construction of the gallery was completed in December, 1892.

NEWTON.

Chemical Examination of Water from the Filter-Gallery, Newton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8447	Jan. 25	Jan. 26	None.	V.slight.	0.00	5.05	.0000	.0008	.29	.0200	.0000	2.5	-
8538	Feb. 18	Feb. 19	None.	None.	0.00	5.50	.0000	.0024	.30	.0150	.0000	2.2	-
8643	Mar. 21	Mar. 22	None.	None.	0.00	5.05	.0000	.0012	.30	.0200	.0000	1.9	-
8802	Apr. 25	Apr. 26	None.	V.slight.	0.00	4.85	.0000	.0020	.31	.0250	.0000	1.8	-
8923	May 23	May 24	None.	V.slight.	0.00	5.05	.0000	.0000	.30	.0140	.0000	2.2	-
9027	June 21	June 22	V.slight.	Slight.	0.10	6.65	.0000	.0068	.36	.0050	.0000	2.5	-
9140	July 25	July 26	V.slight.	Slight.	0.05	5.10	.0000	.0086	.36	.0030	.0002	2.6	-
9287	Aug. 23	Aug. 23	V.slight.	V.slight.	0.05	5.75	.0012	.0084	.41	.0000	.0001	2.7	.0650
9447	Sept. 26	Sept. 27	V.slight.	Slight, earthy.	0.10	6.35	.0016	.0082	.42	.0100	.0001	2.7	.0140
9618	Nov. 3	Nov. 3	V.slight.	Slight, earthy.	0.01	5.35	.0008	.0026	.37	.0120	.0001	2.3	.0025
9696	Nov. 21	Nov. 21	None.	V.slight.	0.00	5.40	.0004	.0034	.39	.0200	.0002	2.8	.0060
9807	Dec. 19	Dec. 19	None.	None.	0.00	5.45	.0000	.0052	.39	.0180	.0000	2.6	.0020
Av.	....	....	....	....	0.03	5.46	.0003	.0041	.35	.0135	.0001	2.4	.0179

Odor in May and August, faintly unpleasant; in June, distinctly mouldy and disagreeable; in July, distinctly vegetable, becoming disagreeable on standing; in the other months no odor was detected. On heating, the odors disappeared, excepting in the July sample, and a faint vegetable odor was developed in the September sample.——The samples were collected from the filter-gallery at the point where it enters the open filter-basin. A large number of tubular wells are connected with the filter-gallery.

Microscopical Examination of Water from the Filter-Gallery, Newton.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	27	20	23	27	25	22	26	24	28	9	21	20
Number of sample, ...	8447	8538	8643	8802	8923	9027	9140	9287	9447	9618	9696	9807
PLANTS.												
Diatomaceæ. Navicula, .	0	0	10	0	-	0	0	0	0	0	0	0
Fungi. Crenothrix, . . .	2	0	1	0	-	24	5	110	158	0	0	0
Miscellaneous. Zoöglœa, . .	3	0	1	0	-	0	8	2	*	24	35	0
Total, ...	5	0	12	0	-	24	13	112	158	24	35	0

* Present, but quantity not determined.

NEWTON.

Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8448	Jan. 25	Jan. 26	None.	V. slight.	0.02	5.35	.0000	.0008	.30	.0250	.0000	2.5	-
8536	Feb. 18	Feb. 19	V. slight.	None.	0.02	4.75	.0000	.0018	.31	.0220	.0000	2.1	-
8642	Mar. 21	Mar. 22	None.	None.	0.00	4.95	.0002	.0010	.36	.0200	.0000	2.5	-
8801	Apr. 25	Apr. 26	Slight.	V. slight.	0.03	4.80	.0000	.0040	.31	.0090	.0000	1.8	-
8922	May 23	May 24	V. slight.	None.	0.00	4.90	.0000	.0006	.31	.0320	.0000	2.1	-
9028	June 21	June 22	V. slight.	Slight.	0.02	5.20	.0010	.0032	.36	.0280	.0000	1.9	-
9142	July 25	July 26	Slight.	Slight.	0.03	5.05	.0000	.0048	.35	.0090	.0001	2.3	-
9288	Aug. 23	Aug. 23	Slight.	Slight.	0.05	5.40	.0054	.0072	.37	.0050	.0008	2.3	.0800
9446	Sept. 26	Sept. 27	Slight.	Slight.	0.05	5.40	.0004	.0032	.36	.0150	.0001	2.6	.0125
9619	Nov. 3	Nov. 3	None.	V. slight.	0.01	4.80	.0000	.0022	.36	.0150	.0000	2.5	.0070
9697	Nov. 21	Nov. 21	None.	V. slight.	0.00	5.30	.0004	.0026	.40	.0300	.0000	3.0	.0125
9808	Dec. 19	Dec. 19	None.	None.	0.00	5.50	.0000	.0022	.38	.0180	.0000	2.8	.0100
Av.	....	....	....	....	0.02	5.13	.0006	.0028	.35	.0190	.0001	2.4	.0244

Odor of Nos. 8801, 9028, 9142 and 9288, unpleasant, mouldy or disagreeable; of all others, none. On heating, a decidedly disagreeable odor was noted in No. 9142, and a faintly disagreeable one in No. 9446; in other samples, none.——The samples were collected from a faucet at the pumping station, while pumping, and represent a mixture of water from the filter-gallery and the open filter-basin.

Microscopical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	20	23	27	25	22	26	24	28	9	21	20
Number of sample,	8448	8536	8642	8801	8922	9028	9142	9288	9446	9619	9697	9808
PLANTS.												
Diatomaceæ,	3	pr.	2	0	5	pr.	14	5	0	0	0	0
Fragilaria,	0	0	0	0	5	0	1	0	0	0	0	0
Melosira,	0	0	0	0	0	0	6	1	0	0	0	0
Navicula,	0	pr.	0	pr.	0	0	7	1	0	0	0	0
Synedra,	3	pr.	2	0	pr.	pr.	0	3	0	0	0	0
Algæ,	1	1	6	92	80	4	15	44	17	0	0	0
Scenedesmus,	1	1	6	92	80	2	12	44	0	0	0	0
Spirogyra,	0	0	0	pr.	0	2	3	0	17	0	0	0
Fungi. Crenothrix,	0	0	11	1	0	pr.	0	26	0	0	0	0
Miscellaneous. Zoöglœa,	1	2	14	196	0	0	28	62	0	42	28	0
TOTAL,	5	3	33	289	85	4	57	137	17	42	28	0

NEWTON.

Chemical Examination of Water from the New Covered Distributing Reservoir of the Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8446	Jan. 25	Jan. 26	None.	V. slight.	0.02	5.25	.0000	.0012	.33	.0200	.0000	2.3	-
8537	Feb. 18	Feb. 19	V. slight.	None.	0.05	6.20	.0004	.0018	.32	.0180	.0000	2.5	-
8644	Mar. 21	Mar. 22	None.	V. slight.	0.00	5.75	.0006	.0012	.33	.0240	.0000	2.6	-
8800	Apr. 25	Apr. 26	V. slight.	V. slight.	0.00	5.95	.0000	.0036	.32	.0180	.0007	2.7	-
8924	May 23	May 24	V. slight.	V. slight.	0.02	6.75	.0012	.0026	.32	.0300	.0000	3.1	-
9029	June 21	June 22	Slight.	Slight.	0.05	7.75	.0046	.0048	.36	.0400	.0008	3.5	-
9141	July 25	July 26	V. slight.	Slight.	0.03	7.80	.0180	.0080	.35	.0500	.0020	4.1	-
9289	Aug. 23	Aug. 23	V. slight.	Slight	0.05	7.40	.0000	.0034	.36	.0090	.0003	4.0	.0450
9448	Sept. 26	Sept. 27	V. slight.	V. slight.	0.02	6.75	.0004	.0034	.36	.0180	.0001	3.2	.0130
9617	Nov. 3	Nov. 3	Slight, milky.	Cons.	0.03	5.90	.0000	.0046	.35	.0250	.0000	2.8	.0250
9695	Nov. 21	Nov. 21	Slight.	Slight.	0.02	5.60	.0008	.0038	.38	.0280	.0000	2.7	.0330
9806	Dec. 19	Dec. 19	V. slight.	Cons., sand.	0.02	5.65	.0006	.0068	.41	.0150	.0000	2.7	.0050
Av.	....	....	....	....	0.03	6.40	.0022	.0038	.35	.0246	.0003	3.0	.0242

Odor, generally unpleasant or disagreeable, occasionally none.—— The samples were collected from the reservoir.

Microscopical Examination of Water from the New Covered Distributing Reservoir of the Newton Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Nov.	Dec.
Day of examination,	27	20	23	27	25	22	26	24	28	9	21	20
Number of sample,	8446	8537	8644	8800	8924	9029	9141	9289	9448	9617	9695	9806
PLANTS.												
Diatomaceæ,	**3**	**1**	**pr.**	**pr.**	**4**	**pr.**	**0**	**0**	**0**	**15**	**0**	**0**
Melosira,	0	0	0	0	0	0	0	0	0	12	0	0
Synedra,	3	1	pr.	pr.	4	pr.	0	0	0	3	0	0
Algæ,	**1**	**pr.**	**3**	**12**	**8**	**4**	**0**	**12**	**8**	**3**	**0**	**0**
Botrycoccus,	0	0	0	0	0	0	0	12	0	0	0	0
Scenedesmus,	1	pr.	3	12	8	4	0	0	8	3	0	0
Fungi,	**0**	**0**	**0**	**16**	**0**	**0**	**0**	**0**	**54**	**0**	**0**	**0**
Crenothrix,	0	0	0	16	0	0	0	0	54	0	0	0
Molds,	0	0	0	0	0	0	0	0	0	0	0	6
ANIMALS.												
Infusoria. Phacus,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**20**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**2**	**pr.**	**1**	**3**	**pr.**	**34**	**84**	**0**	*****	**174**	**32**	**74**
TOTAL,	6	1	4	31	12	38	84	12	82	192	32	80

* Abundant.

NEWTON.

Underdrains to collect the ground water have been placed beneath all of the sewers in Newton, and in order to ascertain the character of the water discharged by them analyses have been made monthly of samples collected from the main underdrain of the Hyde Brook district. This district has a total area of 510 acres, of which 305 acres, consisting of flat gravelly land and containing a population of 5,000, are provided with sewers and underdrains. The main underdrain is 12 inches in diameter and has an inclination of 0.3 per cent. During the year it has never flowed less than half full and has at times been full. The quantity of water discharged probably ranges from 500,000 to 1,000,000 gallons per day. Sewage was first admitted to the sewers May 1, so that the samples collected before this date could not have been affected by leakage from the sewers into the underdrains; and as the subsequent analyses did not differ materially from those first taken, the whole may be considered as representing the ground water of this district, affected as it is by the use for many years of leaching cesspools.

Chemical Examination of Water from the Main Underdrain of the Hyde Brook Division of the Newton Sewerage System.

[Parts per 1000,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8415	Jan. 11	Jan. 12	Distinct.	Cons.	0.00	26.70	.0154	.0026	3.24	1.1000	.0025	10.3	-
8483	Feb. 2	Feb. 3	Distinct.	Heavy.	0.00	27.80	.0152	.0042	3.23	.8500	.0010	10.6	-
8559	Mar. 1	Mar. 1	V. slight.	Cons.	0.00	23.50	.0094	.0018	3.39	1.6000	.0015	10.2	-
8704	Apr. 3	Apr. 5	Decided.	Heavy.	0.00	23.45	.0114	.0026	2.85	1.5000	.0015	9.4	-
8840	May 3	May 3	Slight.	Cons.	0.00	27.90	.0142	.0018	3.79	1.2500	.0012	11.2	-
8962	June 2	June 2	Slight.	Cons.	0.00	29.65	.0146	.0024	3.90	1.0000	.0020	10.3	-
9079	July 8	July 9	None.	Cons.	0.00	28.50	.0082	.0030	3.42	1.5000	.0014	8.0	-
9199	Aug. 6	Aug. 6	None.	Slight.	0.00	30.10	.0096	.0018	3.48	1.2000	.0007	11.0	-
9324	Sept. 1	Sept. 1	Slight.	Cons.	0.00	28.40	.0130	.0026	2.90	.8000	.0025	10.4	-
9504	Oct. 10	Oct. 10	V. slight.	V. slight.	0.00	28.25	.0058	.0012	2.80	1.1000	.0012	11.5	.0030
9608	Nov. 2	Nov. 2	Distinct.	Slight.	0.05	27.15	.0288	.0060	2.66	1.0000	.0010	10.6	.0125
9777	Dec. 12	Dec. 12	None.	V. slight.	0.00	23.55	.0054	.0054	2.46	1.1000	.0012	8.1	.0000
Av.	....	....	....	....	0.00	27.08	.0126	.0029	3.18	1.1666	.0015	10.1	.0052

Odor, faintly musty, often none.——The samples were collected from the underdrain, at its outlet.

Microscopical Examination.

Many of the samples contained no organisms, and in others *Molds* and *Zoöglœa* only were present in significant numbers. The maximum number of *Molds* was 80 per cubic centimeter, and of *Zoöglœa*, 19.

NORTHAMPTON.

Water Supply of Northampton.

Chemical Examination of Water from the Upper and Lower Storage Reservoirs of the Northampton Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
9405	Sept. 19	pt. 21	V. slight.	V. slight.	0.35	4.50	1.40	.0004	.0092	.0078	.0014	.11	.0030	.0000	1.9
9404	Sept. 19	Sept. 21	V. slight.	V. slight.	0.40	4.65	1.50	.0000	.0108	.0094	.0014	.11	.0030	.0005	1.9

Odor, very faintly vegetable. —— The first sample was collected from the upper reservoir, at Roberts' Meadow; the second, from the lower reservoir at Leeds.

Microscopical Examination.

No. 9405. Diatomaceæ, *Asterionella*, 39; *Fragilaria*, 9; *Melosira*, 3; *Synedra*, 4; *Tabellaria*, 23. Cyanophyceæ, *Chroöcoccus*, 1. Fungi, *Crenothrix*, 150. Total, 229.

No. 9404. Diatomaceæ, *Navicula*, 1. Fungi, *Crenothrix*, 34. Infusoria, *Peridinium*, 1. Total, 36.

North Andover.

Chemical Examination of Water from Great Pond, North Andover.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
9833	Dec. 27	Dec. 28	Slight.	Slight.	0.08	3.45	0.95	.0006	.0188	.0158	.0030	.36	.0070	.0000	2.1

Odor, faintly vegetable, becoming somewhat stronger on heating. —— The sample was collected from the pond near its southerly end, just beneath the ice, two hundred and fifty feet from shore, during an investigation for a new source of water supply for North Andover, and for an additional source of water supply for Melrose. The pond was at the time about eight feet below high-water mark.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 3,004; *Cyclotella*, 66; *Diatoma*, 4; *Synedra*, 42; *Tabellaria*, 82. Algæ, *Nephrocytium*, 2; *Protococcus*, 296; *Raphidium*, 4. Fungi, *Molds*, 3. Infusoria, *Dinobryon*, 9; *Peridinium*, 1; *Suctoria*, 4. Miscellaneous, *Zoöglœa*, 8. Total, 3,522.

Water Supply of North Attleborough.

The works of Fire District No. 1, North Attleborough, were purchased by the town of North Attleborough, Sept. 1, 1892, and the fire district was abolished.

Chemical Examination of Water from the Well of the North Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8749	Apr. 17	Apr. 19	None.	None.	0.0	5.55	.0000	.0006	.54	.0600	.0000	2.6	-
9052	June 29	June 30	None.	None.	0.0	6.85	.0004	.0006	.57	.0550	.0000	3.0	-
9317	Aug. 29	Aug. 30	None.	None.	0.0	5.65	.0034	.0056	.52	.0400	.0001	2.9	.0200
9656	Nov. 9	Nov. 10	Slight.	None.	0.0	5.95	.0000	.0000	.47	.0180	.0001	3.8	.0200
9829	Dec. 21	Dec. 22	None.	V. slight.	0.0	5.75	.0000	.0024	.53	.0350	.0000	2.5	.0075
Av.	....	....	....	....	0.0	5.95	.0008	.0018	.53	.0416	.0000	3.0	.0158

Odor, none.—— The samples were collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

Nos. 8749, 9052 and 9317, no organisms. No. 9656, Miscellaneous, *Zoöglœa*, 42.

Water Supply of Northbridge.—Whitin Machine Works.

Chemical Examination of Water from the Reservoir of the Northbridge Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9246	Aug. 15	Aug. 16	Slight, milky.	Slight.	0.03	3.35	.0000	.0030	.26	.0070	.0001	1.4	.0575

Odor, none; when heated, faintly earthy.—— The sample was collected from the reservoir.

Microscopical Examination.

No organisms.

NORTH READING.

North Reading.

Chemical Examination of Water from Martin's Pond and its Main Feeder.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9270	Aug.17	Aug.18	V.slight.	Slight, dark.	0.85	5.15	2.55	.0000	.0260	.0230	.0030	.31	.0000	.0000	1.6
9271	Aug.17	Aug.18	Slight.	V.slight.	1.10	5.00	2.90	.0000	.0320	.0286	.0034	.26	.0050	.0000	1.8

Odor, distinctly vegetable; of No. 9271, also unpleasant. —— The first sample was collected from the brook which flows into Martin's Pond at its northerly end, at the point where the brook is crossed by the Andover road; the second sample was collected from the pond at its southerly end, one hundred and fifty feet from shore.

Microscopical Examination.

No. 9270. Diatomaceæ, *Melosira*, 1; *Navicula*, 2; *Synedra*, 1. Cyanophyceæ, *Oscillaria*, 1. Algæ, *Conferva*, 1. Fungi, *Crenothrix*, 156. Miscellaneous, *Zoöglœa*, 24. Total, 186.

No. 9271. Fungi, *Crenothrix*, 1. Infusoria, *Peridinium*, 1. Vermes, *Sacculus*, 1. Crustacea, *Cyclops*, .02. Total, 3.

Water Supply of Norwood.

An unusually large number of samples was collected from this water supply during the year, owing to the prevalence of a growth of the organism *Uroglena* in Buckmaster Pond from February to May. For a description of this organism and an account of the effect which it has upon the taste and odor of water, the reader is referred to a paper on *Uroglena* in the Twenty-third Annual Report of the State Board of Health, pages 645 to 658.

Chemical Examination of Water from a Brook which flows into Buckmaster Pond, Dedham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8518	Feb. 16	Feb. 17	Slight.	Heavy, earthy.	0.10	2.80	1.20	.0040	.0466	.0126	.0340	.31	.0100	.0002	0.5

Odor, faintly vegetable. —— The sample was collected from the small brook entering Buckmaster Pond from the west.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Epithemia*, 1; *Melosira*, 5; *Meridion*, 18; *Navicula*, 4; *Pinnularia*, 1; *Synedra*, 44; *Tabellaria*, 2. Algæ, *Hyalotheca*, 1; *Spirogyra*, 5. Miscellaneous, *Zoöglœa*, 4. Total, 87.

NORWOOD.

Chemical Examination of Water from Buckmaster Pond, collected at the Surface.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8430	Jan. 18	Jan. 19	Distinct.	Slight, green.	0.10	3.25	1.65	.0050	.0186	.0152	.0034	.31	.0090	.0000	0.3
8517	Feb. 16	Feb. 17	Slight.	Slight.	0.08	2.90	0.95	.0036	.0338	.0178	.0160	.34	.0100	.0000	0.8
8547	Feb. 23	Feb. 24	Distinct, green.	Slight, green.	0.05	2.75	1.25	.0050	.0240	.0176	.0064	.34	.0150	.0001	0.6
8571	Mar. 2	Mar. 3	Decided	Heavy, green.	0.03	2.75	0.75	.0064	.0326	.0162	.0164	.33	.0070	.0001	0.5
8597	Mar. 9	Mar. 10	Decided.	Heavy, green.	0.08	3.15	1.30	.0088	.0594	.0262	.0332	-	.0070	.0004	0.8
8634	Mar. 16	Mar. 18	Distinct, green.	Slight, green.	0.08	3.00	0.60	.0036	.0184	.0154	.0030	.32	.0100	.0000	0.8
8651	Mar. 23	Mar. 24	Slight.	Cons.	0.05	2.90	1.00	.0008	.0260	.0218	.0042	-	.0100	.0001	0.6
8682	Mar. 30	Mar. 31	Distinct.	Slight.	-	-	-	-	-	-	-	-	-	-	-
8715	Apr. 6	Apr. 7	Distinct, green.	Cons., green.	0.10	-	-	-	-	-	-	-	-	-	-
8735	Apr. 13	Apr. 14	Distinct.	Slight.	0.10	3.00	1.25	.0020	.0208	.0154	.0054	.32	.0150	.0000	1.1
8765	Apr. 20	Apr. 21	Distinct, green.	Cons., green.	-	-	-	-	-	-	-	-	-	-	-
8809	Apr. 27	Apr. 28	Distinct.	Slight, green.	0.10	-	-	-	-	-	-	-	-	-	-
8846	May 4	May 5	Decided.	Slight.	0.10	-	-	-	-	-	-	-	-	-	-
8909	May 18	May 19	Distinct.	Cons., green.	0.05	3.50	1.75	.0002	.0276	.0206	.0070	.28	.0020	.0000	0.6
8990	June 13	June 13	Distinct.	Slight.	0.05	3.40	1.40	.0004	.0178	.0148	.0030	.38	.0000	.0000	0.6
9104	July 13	July 14	Slight.	Slight.	0.05	3.25	1.85	.0006	.0204	.0168	.0036	.38	.0000	.0000	0.7
9230	Aug. 10	Aug. 11	V. slight.	V. slight.	0.08	2.85	1.05	.0000	.0202	.0182	.0020	.32	.0000	.0000	0.8
9371	Sept. 14	Sept. 15	Slight.	V. slight.	0.10	2.45	0.95	.0006	.0148	.0136	.0012	.30	.0090	.0000	0.7
9523	Oct. 12	Oct. 13	Slight.	Slight.	0.10	2.10	0.75	.0000	.0216	.0198	.0018	.32	.0070	.0000	0.3
9666	Nov. 14	Nov. 15	Distinct.	V. slight.	0.05	2.45	1.15	.0016	.0196	.0178	.0018	.35	.0070	.0001	0.6
9778	Dec. 12	Dec. 13	Slight.	V. slight.	0.04	2.55	1.05	.0036	.0180	.0162	.0018	.25	.0100	.0001	1.2
Av.	....	....	....	....	0.07	2.88	1.24	.0019	.0219	.0172	.0047	.32	.0067	.0000	0.7

Odor, January to May, vegetable and frequently very disagreeable and oily; on heating, the odor generally increased, and was strongly oily and disagreeable. From June to October the odor was vegetable, and in the first months disagreeable, decreasing to none in October. In November the oily odor was again detected. —— The samples were collected from the pond, a few inches beneath the surface, generally from one to two hundred feet from shore.

Note. — In this and preceding tables, where more than one sample has been collected in a month, the mean analysis for that month has been used in making the average given at the bottom of the table.

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, collected at the Surface.

[Number of organisms per cubic centimeter.]

	1892.									
	Jan.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.	Mar.	Apr.	Apr.
Day of examination,	20	18	24	3	9	19	24	31	8	14
Number of sample,	8430	8517	8547	8571	8597	8634	8651	8682	8715	8735
PLANTS.										
Diatomaceæ,	9	8	300	0	0	349	0	4	5	8
Asterionella,	4	0	0	0	0	0	0	0	2	8
Cyclotella,	2	0	0	0	0	4	0	0	pr.	0
Fragilaria,	0	0	0	0	0	17	0	0	0	0
Melosira,	0	0	0	0	0	0	0	1	0	0
Navicula,	0	1	0	0	0	0	0	pr.	0	0
Synedra,	3	7	300	0	0	328	0	3	3	0
Cyanophyceæ,	0	0	0	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	0	0	0	0
Microcystis,	0	0	0	0	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	0	0
Algæ,	5,548	0	0	0	0	1	0	0	0	0
Chlorococcus,	5,548	0	0	0	0	0	0	0	0	0
Scenedesmus,	0	0	0	0	0	1	0	0	0	0
Fungi. Fungus,	0	0	0	0	0	0	0	0	0	0
ANIMALS.										
Rhizopoda. Actinophrys,	0	0	0	0	0	0	0	0	pr.	0
Infusoria,	6	1,127	400	850	2,000	217	648	49	210	7,727
Cryptomonas,	0	0	0	0	0	0	0	0	0	0
Dinobryon,	6	7	100	0	100	0	0	0	0	0
Dinobryon cases,	0	120	0	0	0	1	4	1	pr.	0
Heteronema,	0	0	0	100	0	0	0	0	0	0
Peridinium,	0	0	0	0	0	0	0	pr.	0	0
Peridinium cases,	0	0	0	0	0	0	0	0	0	0
Uroglena,	0	1,000	300	750	1,900	216	644	48	210	7,727*
Vermes. Anurea,	0	0	0	0	0	0	0	0	0	0
Crustacea. Cyclops,	0	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	5	0	0	0	0	0	0	36	0	0
TOTAL,	5,568	1,135	700	850	2,000	567	648	89	215	7,735

* In this instance the individual organisms were counted and recorded, while in all other cases the customary rule of counting the number of colonies was followed. The average number of individuals per colony is about 1,100.

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, collected at the Surface — Concluded.

[Number of organisms per cubic centimeter.]

	1892.										
	Apr.	Apr.	May.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	29	5	19	14	14	12	15	13	15	13
Number of sample,	8765	8809	8846	8909	8990	9104	9230	9371	9523	9666	9778
PLANTS.											
Diatomaceæ,	18	47	0	5	6	5	pr.	4	41	20	47
Asterionella,	0	5	0	0	0	4	0	4	19	8	20
Cyclotella,	1	1	0	0	pr.	pr.	pr.	0	pr.	0	11
Fragilaria,	0	0	0	0	0	0	0	0	0	0	0
Melosira,	6	25	0	0	3	0	0	0	21	8	3
Navicula,	7	0	0	0	0	0	pr.	0	0	1	0
Synedra,	4	16	0	5	3	1	pr.	0	1	3	13
Cyanophyceæ,	0	0	0	0	0	12	0	0	20	0	0
Chroöcoccus,	0	0	0	0	0	0	0	0	10	0	0
Microcystis,	0	0	0	0	0	0	0	0	10	0	0
Nostoc spores,	0	0	0	0	0	12	0	0	0	0	0
Algæ,	0	2	0	0	0	0	14	0	4	9	0
Chlorococcus,	0	0	0	0	0	0	14	0	4	1	0
Scenedesmus,	0	2	0	0	0	0	0	0	pr.	8	0
Fungi. Fungus,	0	0	0	0	0	0	0	90	0	0	0
ANIMALS.											
Rhizopoda. Actinophrys,	0	0	0	0	0	0	0	0	2	0	0
Infusoria,	19,220	900	1,200	165	4	50	7	1	20	8	19
Cryptomonas,	0	0	50	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	0	0	0	10	0	0
Dinobryon cases,	0	0	0	0	0	0	0	0	10	4	10
Heteronema,	0	0	0	0	0	0	0	0	0	0	0
Peridinium,	0	0	0	0	4	45	7	1	0	1	6
Peridinium cases,	0	0	0	0	0	5	0	0	0	0	0
Uroglena,	19,220*	900	1,150	165	0	0	0	0	0	3	3
Vermes. Anurea,	0	0	0	0	0	1	pr.	0	1	0	0
Crustacea. Cyclops,	0	0	0	0	0	0	0	0	0	0	.10
Miscellaneous. Zoöglœa,	0	0	0	0	34	3	9	0	30	100	0
TOTAL,	19,238	949	1,200	170	44	71	30	95	118	137	66

* In this instance the individual organisms were counted and recorded, while in all other cases the customary rule of counting the number of colonies was followed. The average number of individuals per colony is about 1,100.

NORWOOD.

Chemical Examination of Water from Buckmaster Pond, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8507	Feb. 12	Feb. 13	Decided.	Cons.	0.05	4.25	2.05	.0048	.0516	.0204	.0312	.32	.0100	.0001	0.8
8548	Feb. 23	Feb. 24	Slight.	Slight.	0.05	3.10	1.30	.0076	.0162	.0142	.0020	.35	.0200	.0001	0.8
8572	Mar. 2	Mar. 3	Distinct.	V. slight.	0.08	3.20	1.55	.0090	.0190	.0158	.0032	.34	.0150	.0000	0.3
8598	Mar. 9	Mar. 10	Distinct.	Cons., green.	0.08	3.05	1.00	.0086	.0172	.0150	.0022	.34	.0140	.0001	0.6
8635	Mar. 16	Mar. 18	Slight.	Slight.	0.08	3.25	1.30	.0060	.0160	.0140	.0020	.32	.0120	.0000	0.8
8652	Mar. 23	Mar. 24	Slight.	Cons.	0.05	3.15	1.00	.0056	.0178	.0114	.0064	-	.0180	.0001	0.9
8683	Mar. 30	Mar. 31	Slight.	Slight.	-	-	-	-	-	-	-	-	-	-	-
8716	Apr. 6	Apr. 7	Slight, green.	Slight, green.	0.10	-	-	-	-	-	-	-	-	-	-
8736	Apr. 13	Apr. 14	Distinct.	Slight.	0.10	3.15	1.00	.0020	.0184	.0140	.0044	.34	.0120	.0000	0.8
8766	Apr. 20	Apr. 21	Distinct, green.	Cons., green.	-	-	-	-	-	-	-	-	-	-	-
8810	Apr. 27	Apr. 28	Distinct.	Cons., green.	0.10	-	-	-	-	-	-	-	-	-	-
8847	May 4	May 5	Decided.	Slight.	0.10	-	-	-	-	-	-	-	-	-	-
8910	May 18	May 19	Distinct.	Cons., green.	0.10	3.70	1.90	.0004	.0276	.0220	.0056	.30	.0060	.0000	0.5
8991	June 13	June 16	Distinct.	Cons., white.	0.05	3.85	1.45	.0012	.0198	.0174	.0024	.38	.0000	.0000	0.6
9103	July 13	July 14	Slight.	Slight.	0.05	2.90	1.10	.0000	.0184	.0156	.0028	.35	.0030	.0000	0.6
Av.	....	....	....	....	0.07	3.40	1.39	.0028	.0226	.0167	.0059	.34	.0084	.0000	0.6

Odor, generally vegetable, frequently oily or disagreeable, rarely none; on heating, a strongly oily odor was developed from March to May. —— The samples were collected from the pond near the bottom, where the depth varied from eighteen to twenty-two feet.

Microscopical Examination of Water from Buckmaster Pond, collected near the Bottom.

[Number of organisms per cubic centimeter.]

	1892. Feb.	Feb.	Mar.	Mar.	Mar.	Mar.	Mar.	Apr.	Apr.	Apr.	Apr.	May.	May.	June.	June.
Day of examination,	13	24	3	9	19	24	31	8	14	21	29	5	19	14	14
Number of sample,	8507	8548	8572	8598	8635	8652	8683	8716	8736	8766	8810	8847	8910	8991	9103
PLANTS.															
Diatomaceæ,	0	26	13	0	1	8	pr.	17	0	27	8	0	10	10	1
Asterionella,	0	24	13	0	0	8	0	3	0	6	0	0	0	0	0
Cyclotella,	0	0	pr.	0	1	0	0	0	0	0	0	0	0	6	pr.
Melosira,	0	0	0	0	0	0	0	2	0	16	3	0	0	0	0
Synedra,	0	2	0	0	0	0	pr.	12	0	5	5	0	10	4	1
Cyanophyceæ. Anabæna,	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, collected near the Bottom — Concluded.

[Number of organisms per cubic centimeter.]

	1892.														
	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.	Mar.	Apr.	Apr.	Apr.	Apr.	May.	May.	June.	June.
ANIMALS.															
Infusoria,	**5,160**	**3**	**55**	**300**	**151**	**115**	**38**	**66**	**72**	**17,366**	**425**	**750**	**280**	**1**	**34**
Dinobryon,	8	1	12	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	152	1	36	0	16	100	0	16	0	6	1	0	0	0	0
Euglena,	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
Peridinium,	0	0	pr.	0	0	1	pr.	pr.	34	0	0	0	0	1	34
Uroglena,	5,000	1	7	300	135	0	38	50	38	17,360*	424	750	280	0	0
Crustacea,	**0**	**0**	**.07**	**0**	**.07**	**0**	**0**	**0**	**.01**	**0**	**0**	**0**	**0**	**0**	**0**
Cyclops,	0	0	.03	0	.04	0	0	0	.01	0	0	0	0	0	0
Daphnia,	0	0	.04	0	.03	0	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**0**	**7**	**36**	**0**	**1**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**104**	**3**
TOTAL,	5,160	36	104	300	153	123	38	83	72	17,393	433	750	290	125	38

* Individuals.

Chemical Examination of Water from a Faucet in the Village of Norwood, supplied from Buckmaster Pond.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8519	Feb. 16	Feb. 17	V.slight.	V.slight.	0.08	2.90	0.80	.0070	.0158	.0142	.0016	.33	.0150	.0000	0.8
8579	Mar. 4	Mar. 4	V.slight.	V.slight.	0.05	2.95	1.20	.0068	.0112	.0096	.0016	.35	.0100	.0000	0.5
8599	Mar. 9	Mar. 10	V.slight.	V.slight.	0.08	3.20	0.55	.0084	.0126	.0102	.0024	.33	.0090	.0001	0.6
8636	Mar. 16	Mar. 18	Slight.	V.slight.	0.08	3.30	0.85	.0024	.0168	.0142	.0026	.31	.0140	.0000	0.6
8653	Mar. 23	Mar. 24	None.	V.slight.	0.08	3.05	1.25	.0056	.0140	.0128	.0012	-	.0180	.0001	1.1
8684	Mar. 30	Mar. 31	Slight.	Slight.	-	-	-	-	-	-	-	-	-	-	-
8717	Apr. 6	Apr. 7	V.slight.	V.slight.	0.08	-	-	-	-	-	-	-	-	-	-
8737	Apr. 13	Apr. 14	V.slight	V.slight.	0.10	3.70	0.90	.0010	.0172	.0128	.0044	.32	.0180	.0000	0.6
8767	Apr. 20	Apr. 21	V.slight.	V.slight.	-	-	-	-	-	-	-	-	-	-	-
8811	Apr. 27	Apr. 28	V.slight.	V.slight.	0.10	-	-	-	-	-	-	-	-	-	-
8848	May 4	May 5	V.slight.	Slight.	0.10	-	-	-	-	-	-	-	-	-	-
8911	May 18	May 19	Distinct, milky.	V.slight.	0.05	4.00	1.65	.0004	.0212	.0164	.0048	.28	.0050	.0000	1.6
8992	June 13	June 13	Slight.	Slight, rusty.	0.05	3.30	1.55	.0012	.0160	.0110	.0050	.35	.0000	.0000	0.6
9105	July 13	July 14	V.slight.	Slight.	0.05	3.00	1.25	.0006	.0140	.0120	.0020	.36	.0000	.0000	0.8
9231	Aug. 10	Aug. 11	V.slight.	V.slight.	0.05	2.90	0.90	.0004	.0180	.0178	.0002	.33	.0450	.0001	0.9
9372	Sept. 14	Sept. 15	V.slight.	V.slight.	0.05	2.40	0.90	.0000	.0134	.0122	.0012	.30	.0100	.0000	0.7
9524	Oct. 12	Oct. 13	Slight.	Slight.	0.10	2.55	0.85	.0000	.0212	.0152	.0060	.33	.0030	.0000	1.1
9667	Nov. 14	Nov. 15	V.slight.	V.slight.	0.05	2.45	1.05	.0000	.0124	.0108	.0016	.34	.0100	.0000	1.1
9779	Dec. 12	Dec. 13	Slight, milky.	V.slight.	0.05	3.00	1.00	.0026	.0156	.0142	.0014	.25	.0120	.0001	1.3
Av.	....	....	....	....	0.06	3.03	1.07	.0017	.0162	.0135	.0027	.32	.0119	.0000	0.9

Odor of the first three samples, vegetable; of Nos. 8636 to 8911 inclusive, oily, sometimes strong and disagreeable; of the remaining samples, none, except a vegetable odor in July and August.

NORWOOD.

Chemical Examination of Water from a Faucet in Norwood, supplied from Buckmaster Pond.

[Number of organisms per cubic centimeter.]

	1892.																		
	Feb.	Mar.	Mar.	Mar.	Mar.	Mar.	Apr.	Apr.	Apr.	Apr.	May.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	28	10	9	19	24	31	8	14	21	29	5	19	14	14	12	15	13	15	13
Number of sample,	8519	8579	8599	8636	8653	8684	8717	8737	8767	8811	8848	8911	8992	9105	9231	9372	9524	9667	9779
PLANTS.																			
Diatomaceæ	**181**	**36**	**91**	**11**	**1**	**5**	**18**	**18**	**5**	**74**	**3**	**4**	**30**	**4**	**1**	**10**	**12**	**1**	**17**
Asterionella,	19	2	3	8	pr.	5	3	3	2	5	0	4	13	1	0	6	4	0	6
Cyclotella,	2	0	pr.	2	1	0	0	0	0	0	1	0	pr.	1	0	0	0	0	2
Diatoma,	2	pr.	0	0	0	0	2	0	0	29	0	0	0	1	0	0	0	0	0
Melosira,	0	0	0	0	0	0	0	0	0	0	1	0	13	0	0	0	5	0	0
Synedra,	158	34	88	1	pr.	0	12	15	3	39	1	0	4	1	1	0	3	pr.	4
Tabellaria,	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	4	0	1	5
Algæ,	**7**	**6**	**1**	**2**	**0**	**0**	**1**	**0**	**10**	**4**	**0**	**0**	**0**	**0**	**4**	**0**	**10**	**0**	**6**
Chlorococcus,	4	5	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4
Raphidium,	0	pr.	0	pr.	0	0	0	0	10	4	0	0	0	0	1	0	10	0	0
Staurastrum,	3	1	1	2	0	0	1	0	pr.	0	0	0	0	0	0	0	pr.	0	2
ANIMALS.																			
Infusoria,	**2**	**pr.**	**1**	**1,451**	**1**	**1,068**	**13**	**0**	**250**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**4**	**0**	**3**
Dinobryon,	2	0	0	1	0	2	0	0	pr.	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	pr.	1	38	1	0	13	0	1	0	0	0	0	0	0	0	4	0	3
Peridinium,	0	0	0	pr.	0	pr.	0	0	1	0	0	0	0	1	1	0	0	0	0
Uroglena,	0	0	0	1,412	0	1,066	0	0	248	0	0	0	0	0	0	0	0	0	0
Miscellaneous.																			
Zoöglœa,	**36**	**70**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**1**	**1**	**0**	**1**	**34**	**8**
TOTAL,	226	112	102	1,464	2	1,073	32	18	265	78	8	4	30	6	7	10	27	35	34

Table of Heights of Water in Buckmaster Pond on the First Day of Each Month.

DATE.	Distance below Crest of Dam.	DATE.	Distance below Crest of Dam.
1892.	Feet.	1892 — Con.	Feet.
Jan. 1,	2.5	Aug. 1,	1.5
Feb. 1,	0.7	Sept. 1,	2.3
March 1,	0.1	Oct. 1,	3.5
April 1,	0.0	Nov. 1,	4.9
May 1,	0.0	Dec. 1,	4.6
June 1,	0.6	1893.	
July 1,	0.6	Jan. 1,	5.1

Water Supply of Orange.

Chemical Examination of Water from North Pond, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid Total.	Ammonia. Albuminoid Dissolved.	Ammonia. Albuminoid Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9454	Sept. 27	Sept. 29	Distinct.	Slight.	0.10	2.55	1.15	.0000	.0144	.0124	.0020	.11	.0050	.0003	0.8

Odor, very faintly vegetable. —— The sample was collected about two hundred feet from the southwesterly shore.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 20; *Melosira*, 24. Tabellaria, 2. Rhizopoda, *Actinophrys*, 1. Total, 47.

Chemical Examination of Water from Coolidge Brook, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9117	July 14	July 15	V. slight.	V. slight.	0.35	3.30	1.05	.0004	.0104	.0098	.0006	.06	.0030	.0001	2.2
9118	July 14	July 15	V. slight.	V. slight.	0.35	3.20	1.05	.0004	.0094	.0084	.0010	.12	.0030	.0001	1.4
9455	Sept. 27	Sept. 29	V. slight.	Slight.	0.20	3.15	0.95	.0000	.0054	.0046	.0008	.16	.0030	.0003	0.7
Av.	....	....	....	....	0.30	3.22	1.02	.0003	.0084	.0076	.0008	.11	.0030	.0002	1.4

Odor of the first sample, faintly vegetable; of the others, none. On heating, the odor of the first two samples was faintly vegetable, and of the third, none. —— The first sample was collected from the brook at the site of an old dam, about three-quarters of a mile below the Holshire road; the other samples were collected at the point where the Holshire road crosses the brook.

Microscopical Examination.

The number of organisms in these samples ranged from 6 to 28, averaging 14 per cubic centimeter.

Water Supply of Pittsfield.

In the summer of 1892 the city of Pittsfield built a reservoir on Hathaway Brook, a stream which drains the territory included between the watersheds of the two brooks from which a gravity

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supply is now taken. This stream is much smaller than either of those now used. The reservoir, which is somewhat higher than that on Ashley Brook, is connected by means of a ten-inch pipe with the sixteen-inch main which now supplies water to the city from Ashley Reservoir.

The advice of the State Board of Health relative to an additional water supply for the city of Pittsfield from Hathaway and other brooks may be found on page 39 of this volume.

Water Supply of Plymouth.

The analyses of samples from different sources connected with the Plymouth water works as given in tables which follow were nearly all made at a time when the water supply was affected by a growth of the organism *Uroglena* in Little South Pond. A description of this organism and its effect upon the taste and odor of water may be found in the Twenty-third Annual Report of the State Board of Health, pages 645 to 658.

Chemical Examination of Water from Great South Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8624	Mar. 14	Mar. 16	None.	V. slight.	0.0	2.50	1.05	.0000	.0066	.0054	.0012	.65	.0030	.0000	0.0

Odor, none.——The sample was collected from the pond at the entrance to the culvert leading to Little South Pond.

Microscopical Examination.

Diatomaceæ, *Fragilaria*, 4; *Navicula*, 3; *Synedra*, 44. Algæ, *Scenedesmus*, 1. Infusoria, *Dinobryon cases*, 1. Miscellaneous, *Zooglœa*, 2. Total, 55.

PLYMOUTH.

Chemical Examination of Water from Little South Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8593	Mar. 8	Mar. 10	Slight.	Slight.	0.00	2.45	0.85	.0008	.0142	.0120	.0022	.66	.0050	.0000	0.2
8623	Mar. 15	Mar. 16	Slight.	Slight.	0.00	3.10	1.30	.0004	.0114	.0096	.0018	.68	.0040	.0000	0.2
8667	Mar. 23	Mar. 26	None.	V. slight.	0.00	-	-	.0018	.0114	.0084	.0030	.54	-	.0000	0.2
8712	Apr. 5	Apr. 6	Slight.	Slight.	0.00	-	-	-	-	-	-	-	-	-	-
8743	Apr. 18	Apr. 19	Slight.	V. slight.	0.01	-	-	-	-	-	-	.64	-	-	-
9026	June 21	June 22	V. slight.	Slight.	0.02	2.90	1.00	.0000	.0116	.0086	.0030	.64	.0000	.0000	0.0
Av.	....	....	....	....	0.00	2.82	1.05	.0009	.0121	.0096	.0025	.63	.0030	.0000	0.1

Odor of No. 8667, none; of No. 8593 when received, none, next day, unpleasant; of Nos. 8623 and 8743, faintly vegetable; of No. 8712, very faintly oily when received, stronger next day; of No. 9026, vegetable and grassy; on heating, a decidedly oily odor was developed in Nos. 8593, 8712 and 8743, a disagreeable odor was noted in Nos. 8623 and 8667, and a vegetable and grassy odor in No. 9026.—The samples were collected from the pond at the point from which water is drawn for the supply of the town, with the exception of No. 8667, which was collected from the pond at its natural outlet.

Microscopical Examination of Water from Little South Pond, Plymouth.

[Number of organisms per cubic centimeter.]

	1892.					
	March.	March.	March.	April.	April.	June.
Day of examination,	10	-	26	6	19	22
Number of sample,	8593	8623	8667	8712	8743	9026
PLANTS.						
Diatomaceæ,	**561**	**9**	**2**	**4**	**3**	**8**
Asterionella,	2	0	2	4	0	8
Cyclotella,	56	pr.	0	pr.	0	0
Diatoma,	154	0	0	0	0	0
Melosira,	3	1	0	0	0	0
Synedra,	346	8	0	pr.	3	0
Cyanophyceæ. Anabæna,	**0**	**0**	**0**	**0**	**0**	**192**
ANIMALS.						
Infusoria,	**60**	**63**	**15**	**2**	**18**	**0**
Dinobryon,	0	2	0	0	0	0
Dinobryon cases,	0	25	7	2	1	0
Trachelomonas,	pr.	0	0	pr.	0	0
Uroglena,	60	36	8	pr.	17	0
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**.01**	**0**
Miscellaneous. Zoöglœa,	**2**	**3**	**1**	**0**	**0**	**4**
TOTAL,	623	75	18	6	21	204

PLYMOUTH.

Chemical Examination of Water from Lout Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8621	Mar. 15	Mar. 16	V. slight.	V. slight.	0.40	3.30	1.60	.0006	.0170	.0142	.0028	.71	.0100	.0000	0.2
8622	Mar. 15	Mar. 16	V. slight.	V. slight.	0.38	3.35	1.50	.0006	.0154	.0122	.0032	.71	.0100	.0000	0.2
8666	Mar. 23	Mar. 26	V. slight.	V. slight.	0.30	-	-	.0006	.0162	.0150	.0012	-	-	.0000	0.2
Av.	....	....	....	....	0.36	3.32	1.55	.0006	.0162	.0138	.0024	.71	.0100	.0000	0.2

Odor, none; on heating, the odor of the last sample became very faintly vegetable.—— The first two samples were collected from the pond near the pumping station, the first at the surface and the second ten feet beneath the surface; the last sample was collected at the outlet of the pond.

Microscopical Examination of Water from Lout Pond, Plymouth.

[Number of organisms per cubic centimeter.]

	1892.		
	March.	March.	March.
Day of examination,	-	-	26
Number of sample,	8621	8622	8666
PLANTS.			
Diatomaceæ,	61	34	14
Asterionella,	19	26	10
Diatoma,	0	3	1
Navicula,	0	2	0
Synedra,	42	3	3
Algæ. Closterium,	0	0	4
Fungi. Crenothrix,	0	3	2
ANIMALS.			
Infusoria,	0	1	0
Codonella,	0	1	0
Cryptomonas,	pr.	0	0
Heteronema,	0	pr.	0
Peridinium,	0	0	pr.
Miscellaneous. Zoöglœa,	1	4	1
Total,	62	42	21

PLYMOUTH.

Chemical Examination of Water from Boot Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8625	Mar. 14	Mar. 16	V. slight.	V. slight.	0.02	2.70	1.20	.0000	.0120	.0088	.0032	.67	.0100	.0000	0.0

Odor, none, becoming very faintly vegetable on heating.——The sample was collected from the pond at its outlet into Great South Pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 4; *Cyclotella*, 7; *Navicula*, 1; *Synedra*, 8; *Tabellaria*, 2. Infusoria, *Dinobryon cases*, 10. Total, 32.

Chemical Examination of Water from Faucets in Plymouth, supplied from Little South Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8566	Feb. 29	Mar. 2	V. slight.	V. slight.	0.0	-	-	.0004	.0154	.0122	.0032	-	.0000	.0000	0.5
8594	Mar. 8	Mar. 10	Slight.	V. slight.	0.0	3.00	1.20	.0002	.0132	.0110	.0022	.66	.0050	.0001	0.3
8595	Mar. 8	Mar. 10	V. slight.	None.	0.0	2.45	0.70	.0006	.0120	.0102	.0018	.66	.0050	.0000	0.3
8596	Mar. 8	Mar. 10	V. slight.	V. slight.	0.0	2.75	0.65	.0006	.0116	.0100	.0016	.66	.0050	.0001	0.3

Odor of the first sample, vegetable, unchanged on heating; of the second sample, faintly vegetable and unpleasant, becoming disagreeable and oily on heating; of the third sample, none, becoming unpleasant after standing a day in the laboratory; on heating, it became very disagreeable and oily; of the last sample, very faintly vegetable and unpleasant, becoming much stronger after standing a day in the laboratory; on heating, it became disagreeable and oily.——The first two samples were collected from faucets on the low service supplied by a direct pipe from Little South Pond; the third from a faucet at the pumping station, one hour after pumping had ceased; the last from a faucet on the high service, representing water which had passed through the reservoir.

PLYMOUTH.

Microscopical Examination of Water from Faucets in Plymouth, supplied from Little South Pond.

[Number of organisms per cubic centimeter.]

	1892.			
	March.	March.	March.	March.
Day of examination,	2	10	10	10
Number of sample,	8566	8594	8595	8596
PLANTS.				
Diatomaceæ,	**8**	**35**	**2**	**7**
Asterionella,	5	1	0	3
Cyclotella,	2	0	0	0
Diatoma,	0	4	0	0
Synedra,	1	30	2	4
ANIMALS.				
Infusoria,	**24**	**6**	**6**	**4**
Dinobryon,	1	2	0	0
Dinobryon cases,	22	4	5	4
Peridinium,	1	0	0	0
Uroglena,	0	0	1	0
Crustacea. Bosmina,	**0**	**0**	**.02**	**.01**
Miscellaneous. Zoöglœa,	**6**	**0**	**4**	**3**
TOTAL,	38	41	12	14

WATER SUPPLY OF PROVINCETOWN.

In 1889 an investigation was made with a view to obtaining a water supply for Provincetown, and the advice of the State Board of Health to the town at that time may be found in the annual report of the Board for that year, page 21. This investigation showed that there were no surface-water sources from which a water of suitable quality could be obtained, and that the ground water was different from that in other parts of the State, owing to the peculiar manner in which the land in and about Provincetown has been formed. The town is situated at the extreme end of Cape Cod, where the land has been formed of sand drifted by ocean currents or blown by the wind, and almost everywhere contains beneath the level of the water in the ground more or less organic matter, largely of marine origin.

The Board, as a part of the advice above referred to, recommended that more complete examinations be made before any water supply

was introduced; and in 1892 the water board of the town made examinations in accordance with this advice. As a result of these examinations, the water board concluded that a certain territory about three-fourths of a mile north of the centre of the village was the most suitable one for obtaining a water supply.

Small test wells were driven at frequent intervals over a considerable area, to determine the character of the ground and the quality of the water, and at six points where the indications were the most favorable, larger tubular wells, five inches in diameter, were sunk. The extreme wells were about four hundred feet apart in an easterly and westerly direction, and two hundred feet northerly and southerly. These wells were connected with a steam pump and subjected to a pumping test which began August 2 and ended September 1. The pump was run during the daytime every week-day. Samples of water were collected at intervals from the pump while pumping from all of the wells, and while pumping only from Well No. 3, which, at the time when the first sample was taken, supplied a water having less color than either of the other wells. One sample was also collected from this well after the pumping test had ceased, by using a hand pump.

Analyses are also given, in tables which follow, of samples of water collected from test wells at various points within the limits of the town and of several private wells in the village.

The advice of the State Board of Health to the water board of Provincetown, after the conclusion of the investigations in 1892, may be found on pages 41 to 44 of this volume.

PROVINCETOWN.

Chemical Examination of Water from a Gang of Six Tubular Test Wells at Provincetown.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9235	Aug. 11	Aug. 12	Distinct, milky.	Slight.	0.70	7.35	.0026	.0090	2.09	.0070	.0001	1.4	.4750
9250	Aug. 15	Aug. 16	Distinct, milky.	Cons., yellow.	0.75	7.65	.0010	.0066	2.10	.0100	.0000	1.1	.2000
9279	Aug. 19	Aug. 20	Distinct, milky.	Cons., stringy.	0.90	7.60	.0030	.0090	2.20	.0070	.0000	1.4	.5300
9299	Aug. 24	Aug. 25	Cl'r when received.	None.	0.58	7.85	.0042	.0060	2.17	.0070	.0001	2.2	.2750
9318	Aug. 29	Aug. 30	Cl'r when received.	Slight, rusty.	0.80	8.40	.0016	.0054	2.14	.0090	.0000	1.8	.4400
9326	Aug. 31	Sept. 1	Distinct, milky.	Slight.	0.75	8.30	.0050	.0110	2.22	.0050	.0000	1.8	.4500

The turbidity of No. 9250 increased on standing, and Nos. 9299 and 9318, though clear when received, became milky in appearance the next day. The color of the samples generally increased on standing, No. 9326 having a color of 1.00 after standing three days.

Odor of No. 9235, distinctly vegetable and somewhat unpleasant; of No. 9279, very faintly vegetable; of No. 9326, distinct; of the others, none. When heated, the odor was generally faintly vegetable; the last sample was odorless. —— The samples were collected during a pumping test from six tubular wells, five inches in diameter, which were connected with a steam pump. The test was begun on August 2, and continued every week-day until September 1.

Microscopical Examination.

No organisms were found in any of the samples. Iron rust was present in the last two.

Chemical Examination of Water from Test Well No. 3, Provincetown.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9314	Aug. 26	Aug. 27	Decided, milky.	Cons., rusty.	0.45	8.00	.0012	.0048	2.21	.0030	.0001	1.6	.3400
9319	Aug. 29	Aug. 30	Decided, milky.	Slight, rusty.	0.70	7.90	.0000	.0000	2.28	.0090	.0000	1.6	.3600
9325	Aug. 31	Sept. 1	Distinct, milky.	Slight.	0.70	8.10	.0032	.0092	2.16	.0050	.0000	2.1	.3600
9462	Sept. 28	Sept. 29	Distinct, milky.	Slight, earthy.	0.83	7.90	.0004	.0016	–	.0070	.0000	–	.1700

As a rule the samples were nearly clear when received, but became milky in appearance on standing in the laboratory; the color also increased on standing.

Odor, none. On heating, a faintly earthy odor was developed in No. 9319. —— The first three samples were collected while pumping with a steam pump from Well No. 3, one of the six five-inch wells. The last sample was collected while pumping with a hand pump.

Microscopical Examination.

Nos. 9314 and 9462 were not examined. Iron rust only was found in the remaining samples.

PROVINCETOWN.

Chemical Examination of Water from Small Tubular Test Wells at Various Places in Provincetown.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8947	May 25	May 27	Distinct, clayey.	Cons., earthy.	0.60	9.45	.0006	.0170	2.22	.0030	.0001	2.1	-
8946	May 25	May 27	Slight.	Slight.	0.20	7.00	.0000	.0116	2.18	.0050	.0001	0.9	-
9460	Sept. 28	Sept. 29	V. slight, milky.	V. slight, earthy.	0.25	6.10	.0002	.0020	-	.0070	-	-	.0150
9596	Oct. 31	Nov. 1	Slight, milky.	V. slight.	0.15	-	.0020	.0076	2.00	.0050	.0000	-	*.1000

The color of No. 9460 increased slightly on standing; that of No. 9596 increased to 0.30 on November 18.

The first sample was collected from a driven well located on the rise of ground midway between Clapp's and Shank Painter ponds; the second sample, from a driven well in the vicinity of the temporary pumping station; the third sample, from a driven well north-east of the temporary pumping station and not far from Well No. 3; the last sample was collected in equal portions from two driven wells one hundred and eighty feet apart, located in the easterly portion of the town, about seventy feet north of the Old Colony Railroad, at a road crossing.

* Approximate.

Microscopical Examination.

No. 8946, Diatomaceæ, *Asterionella*, 1. No. 8947, Miscellaneous, Zoöglœa, 72. No. 9460, not examined. No. 9596, no organisms.

Chemical Examination of Water from Private Wells at Various Places in the Village of Provincetown.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9367	Sept. 13	Sept. 14	Clear.	Slight.	0.00	6.25	.0008	.0060	1.46	.0000	.0000	1.8	*.0775
9368	Sept. 13	Sept. 14	Slight.	Slight.	0.50	37.45	.0004	.0264	9.38	.4800	.0000	8.5	.0110
9425	Sept. 22	Sept. 23	Clear.	None.	0.00	7.85	.0004	.0034	1.74	.0000	.0000	2.3	.1675
9426	Sept. 22	Sept. 23	V. slight.	Slight.	0.50	25.00	.2018	.0256	7.20	.2500	.1000	5.1	.0300
9427	Sept. 22	Sept. 23	V. slight.	V. slight.	1.50	30.25	.0970	.0478	6.16	.5300	.0020	7.0	.0200
9428	Sept. 22	Sept. 23	Slight.	Slight.	0.80	13.90	.0000	.0296	2.60	.1200	.0100	4.3	.0100
9461	Sept. 28	Sept. 29	None.	V. slight, rusty.	0.55	20.90	.0094	.0074	4.60	.3500	.0060	5.7	.0160

Nos. 9367 and 9425 were clear when received, but became milky after standing for a time in the laboratory. The color also in some of the samples increased on standing.

Odor of No. 9426, distinctly disagreeable; of No. 9425, faintly disagreeable; of all others, none. —— The samples were collected as follows: Nos. 9367 and 9425, from a driven well at house of J. D. Adams, near the town hall; No. 9368, from a brick-lined well where water is pumped by an old-fashioned wooden pump, and is used considerably in the neighborhood; No. 9426, from a driven well at house of J. Daggett, near the eastern school-house on Commercial Street; No. 9427, from a tubular well at a house on Bradford Street, opposite Gifford Square; No. 9428, from a driven well in the yard of a house near Franklin Street; No. 9461, from a well in the rear of Alexander Hamlin's house, on Commercial Street.

* Some of the iron in this sample had precipitated before this determination was made.

PROVINCETOWN.

Chemical Examination of Water from a Tubular Well in Provincetown when Fresh, and after standing Three and a Half Years.

[Parts per 100,000.]

Number.	Date of Examination.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Iron.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1889.													
4406	Mar. 27	None.	None.	3.3	8.45	3.60	.0246	.0230	.0216	.0014	1.69	.0090	.0000	–
	1892.													
9290	Aug. 24	V. slight.	Cons., rusty.	1.1	–	–	.0000	.0240	–	–	1.91	.0070	.0001	.4000

Duplicate samples were collected on March 26, 1889, from a tubular well which supplied water of a very dark color. One sample was analyzed as soon as received, and the other was allowed to stand for nearly three and a half years in the office of the State Board of Health, where it was exposed to the light in a room facing toward the north, and was then analyzed, with the result shown in the second line of the table. Notwithstanding this long exposure to the light, the last sample retained one-third of the original deep color. The water had the very disagreeable odor of sulphuretted hydrogen when it was received at the laboratory, but at the end of the three and a half years had no odor.

Water Supply of Quincy.

The city of Quincy purchased the works of the Quincy Water Company, June 1, 1892.

Chemical Examination of Water from Town Brook, just above the Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	18	92.													
8452	Jan. 27	Jan. 28	V. slight.	Slight.	0.50	4.05	1.00	.0000	.0072	.0066	.0006	.68	.0150	.0000	0.6
8555	Feb. 25	Feb. 26	Slight.	Slight.	0.60	3.70	1.10	.0010	.0128	.0108	.0020	.50	.0180	.0002	0.5
8680	Mar. 28	Mar. 29	V. slight.	V. slight.	0.50	3.25	1.05	.0006	.0088	.0074	.0014	.46	.0100	.0000	0.5
8820	Apr. 27	Apr. 28	V. slight.	Slight.	0.70	3.90	1.55	.0004	.0160	.0136	.0024	.55	.0280	.0000	0.6
8940	May 26	May 27	Slight.	Cons.	1.00	4.10	1.70	.0000	.0264	.0214	.0050	.46	.0030	.0001	0.5
9044	June 29	June 30	V. slight.	Slight, rusty.	2.40	6.55	3.25	.0002	.0428	.0370	.0058	.52	.0100	.0001	1.0
9170	July 27	July 28	Slight.	Cons.	1.20	5.30	1.45	.0446	.0418	.0356	.0062	.47	.0090	.0002	0.6
9310	Aug. 25	Aug. 27	V. slight.	Cons.	0.90	4.45	1.40	.0000	.0158	.0116	.0042	.50	.0050	.0002	0.8
9459	Sept. 28	Sept. 29	Slight.	Cons., dark.	0.70	6.40	2.00	.0024	.0220	.0188	.0032	.74	.0200	.0003	0.9
9576	Oct. 26	Oct. 27	V. slight.	V. slight.	0.65	4.40	1.30	.0000	.0082	.0066	.0016	.60	.0070	.0000	0.9
9729	Nov. 28	Nov. 29	V. slight.	Slight.	0.85	4.85	1.70	.0000	.0156	.0122	.0034	.61	.0070	.0001	1.3
9821	Dec. 20	Dec. 21	None.	V. slight.	0.50	3.90	1.20	.0004	.0114	.0086	.0028	.49	.0050	.0000	1.1
Av.	....	....	....	....	0.87	4.57	1.56	.0041	.0191	.0159	.0032	.55	.0114	.0001	0.8

Odor, vegetable and frequently sweetish or grassy, becoming stronger and sometimes also mouldy on heating. —— The samples were collected from the brook above the storage reservoir.

QUINCY.

Microscopical Examination of Water from Town Brook, just above the Storage Reservoir of the Quincy Water Works.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	26	30	29	29	30	29	27	30	28	30	22
Number of sample,	8452	8555	8680	8820	8940	9044	9170	9310	9459	9576	9729	9821
PLANTS.												
Diatomaceæ,	**10**	**264**	**34**	**27**	**37**	**9**	**11**	**pr.**	**213**	**1**	**4**	**6**
Asterionella,	0	0	0	4	5	0	0	0	2	0	0	2
Diatoma,	0	2	27	7	8	1	2	pr.	8	pr.	2	0
Fragilaria,	0	0	0	3	1	0	0	0	0	0	0	1
Melosira,	0	1	0	0	4	0	0	0	12	0	0	0
Meridion,	5	2	5	1	1	0	1	0	2	0	1	pr.
Navicula,	2	1	pr.	3	1	2	4	0	9	0	0	0
Synedra,	3	258	2	9	15	5	4	pr.	0	1	1	1
Tabellaria,	0	0	0	0	2	1	0	0	180	0	0	2
Cyanophyceæ. Clathrocystis,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**24**	**0**	**0**	**0**
Algæ,	**0**	**pr.**	**0**	**0**	**1**	**0**	**0**	**0**	**33**	**0**	**0**	**0**
Hyalotheca,	0	0	0	0	0	0	0	0	28	0	0	0
Scenedesmus,	0	pr.	0	0	1	0	0	0	5	0	0	0
Fungi. Crenothrix,	**1**	**0**	**0**	**0**	**1**	**14**	**88**	**40**	**55**	**15**	**2**	**0**
ANIMALS.												
Infusoria,	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**7**	**0**	**0**	**pr.**
Ceratium,	0	0	0	0	0	0	0	0	2	0	0	0
Peridinium,	0	0	1	0	0	0	1	0	5	0	0	pr.
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**.07**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**pr.**	**12**	**2**	**1**	**42**	**19**	**124**	**38**	*	**5**	**22**	**2**
TOTAL,	11	276	37	28	81	42	224	78	332	21	28	8

* Very abundant.

QUINCY.

Chemical Examination of Water from the Storage Reservoir, Quincy.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved	Ammonia. Albuminoid. Suspended	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8453	Jan. 27	Jan. 28	Slight.	Slight.	0.70	4.20	1.10	.0060	.0144	.0122	.0022	.61	.0100	.0000	0.6
8556	Feb. 25	Feb. 26	Slight.	Slight.	0.40	3.90	1.10	.0016	.0136	.0114	.0022	.64	.0300	.0001	0.6
8681	Mar. 28	Mar. 29	Slight.	Slight.	0.40	3.75	1.25	.0002	.0112	.0094	.0018	.58	.0150	.0000	0.6
8821	Apr. 27	Apr. 28	Slight.	Cons., green.	0.20	3.60	1.35	.0006	.0116	.0104	.0012	.59	.0220	.0000	0.6
8941	May 26	May 27	Distinct, green.	Cons.	0.55	3.40	1.40	.0022	.0232	.0162	.0070	.59	.0050	.0002	0.5
9045	June 29	June 30	Decided, green.	Cons., rusty.	0.60	4.75	2.35	.0000	.0394	.0224	.0170	.54	.0000	.0000	0.8
9171	July 27	July 28	Slight.	Cous., green.	0.65	4.10	1.05	.0000	.0288	.0226	.0062	.59	.0000	.0000	1.2
9311	Aug. 25	Aug. 27	Distinct.	Cons., rusty.	0.90	4.80	1.35	.0018	.0312	.0250	.0062	.65	.0000	.0001	1.3
9458	Sept. 28	Sept. 29	Decided, yellow.	Much rusty.	0.90	4.20	1.55	.0028	.0360	.0236	.0124	.64	.0050	.0004	0.9
9577	Oct. 26	Oct. 27	Distinct.	Cons., green.	0.70	4.10	1.45	.0070	.0296	.0204	.0092	.62	.0150	.0002	0.9
9730	Nov. 28	Nov. 29	Slight.	Slight, yellow.	0.80	3.90	1.50	.0194	.0264	.0192	.0072	.66	.0090	.0000	1.1
9820	Dec. 20	Dec. 21	Distinct, clayey.	Slight, yellow.	0.70	3.95	1.50	.0192	.0196	.0170	.0026	.64	.0070	.0000	1.6
Av.	....	....	....	....	0.62	4.07	1.41	.0051	.0237	.0175	.0062	.61	.0098	.0001	0.9

Odor, faintly vegetable, frequently becoming stronger on heating. —— The samples were collected from the reservoir near the surface at the dam. The reservoir was full, and water was wasting over the rollway most of the time until about the middle of June. From this time the surface lowered gradually until November 9, when it was about six feet below high water. It then began to rise again, and at the end of the year was about four feet below high water.

Microscopical Examination of Water from the Storage Reservoir, Quincy.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	26	30	29	29	30	29	27	29	28	30	22
Number of sample,	8453	8556	8681	8821	8941	9045	9171	9311	9458	9577	9730	9820
PLANTS.												
Diatomaceæ,	**37**	**1**	**2**	**34**	**27**	**381**	**1,416**	**1,004**	**616**	**967**	**401**	**170**
Asterionella,	2	1	0	16	10	240	0	7	8	17	124	14
Cyclotella,	0	0	2	1	6	0	0	0	3	pr.	0	12
Diatoma,	0	0	0	4	1	0	pr.	0	0	0	0	2
Navicula,	0	0	0	pr.	3	0	0	0	4	pr.	1	pr.
Synedra,	35	pr.	0	10	7	72	pr.	1	1	132	4	4
Tabellaria,	0	0	0	3	pr.	69	1,416	996	600	818	272	138

QUINCY.

Microscopical Examination of Water from the Storage Reservoir, Quincy — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	0	0	pr.	1	29	582	294	65	46	2	4	0
Anabæna,	0	0	0	0	9	2	28	1	0	0	0	0
Chroöcoccus,	0	0	0	0	0	12	2	0	0	0	0	0
Clathrocystis,	0	0	pr.	1	20	568	264	64	46	2	4	0
Algæ,	pr.	0	0	0	6	0	31	400	57	581	10	2
Chlorococcus,	pr.	0	0	0	6	0	10	104	0	258	0	0
Cosmarium,	0	0	0	0	0	0	0	2	13	132	0	pr.
Dictyosphærium,	0	0	0	0	0	0	0	0	0	10	0	0
Hyalotheca,	0	0	0	0	0	0	0	116	0	0	0	0
Nephrocytium,	0	0	0	0	0	0	0	8	0	0	2	0
Raphidium,	0	0	0	0	0	0	0	0	22	0	0	1
Scenedesmus,	0	0	0	0	0	0	0	6	11	1	pr.	0
Selenastrum,	0	0	0	0	0	0	0	0	0	0	6	0
Staurastrum,	0	0	0	pr.	0	0	21	164	11	180	2	1
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	1	7	2	0	6	4
Actinophrys,	0	0	0	0	0	0	0	0	2	0	0	1
Difflugia,	0	0	0	0	0	0	1	7	0	0	6	3
Infusoria,	pr.	14	18	5	26	581	294	95	32	44	5	7
Dinobryon,	0	0	3	0	0	0	0	18	0	10	0	4
Dinobryon cases,	0	0	0	pr.	26	51	288	7	0	pr.	0	3
Glenodinium,	0	0	0	0	0	2	0	0	0	0	0	0
Peridinium,	pr.	14	15	5	0	528	0	6	30	0	3	pr.
Trachelomonas,	0	pr.	0	0	0	0	6	64	2	34	2	0
Vermes,	0	0	pr.	pr.	3	1	4	4	2	1	2	0
Anurea,	0	0	pr.	pr.	1	0	3	0	0	1	pr.	0
Monocerca,	0	0	0	0	0	0	0	2	0	0	0	0
Polyarthra,	0	0	0	0	0	1	0	1	0	0	0	0
Rotatorian ova,	0	0	0	0	1	0	0	0	1	0	2	0
Rotifer,	0	0	0	pr.	1	0	1	1	1	0	0	0
Crustacea,	0	0	0	0	0	0	.03	.04	.09	.52	.14	.01
Cyclops,	0	0	0	0	0	0	.03	.04	.09	.02	.14	.01
Entomostracan ova,	0	0	0	0	0	0	0	0	0	.50	0	0
Miscellaneous. Zoöglœa,	58	14	70	144	160	284	410	200	*	284	392	382
TOTAL,	95	29	90	184	251	1,829	2,450	1,775	755	1,879	820	565

* Very abundant.

RANDOLPH.

Water Supply of Randolph and Holbrook.

Chemical Examination of Water from Great Pond in Randolph and Braintree.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8611	Mar. 15.	Mar. 15.	V. slight.	V. slight.	0.50	4.05	1.75	.0018	.0198	.0156	.0042	.57	.0150	.0000	0.9

Odor, distinctly vegetable.—The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Navicula*, 1; *Synedra*, 3. Infusoria, *Dinobryon*, 7; *Peridinium*, 1. Crustacea, *Cyclops*, .01. Miscellaneous, *Zoöglœa*, 50. Total, 64.

Water Supply of Reading.

Chemical Examination of Water from the Filter-Gallery of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.
								Albuminoid.							
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1892.														
8426	Jan. 18	Jan. 19	V. slight.	None.	0.02	10.05	.0054	.0034	-	-	.57	.0050	.0001	3.9	-
8512	Feb. 15	Feb. 16	Distinct, milky.	Cons., ir'n oxide.	0.75	9.00	.0062	.0074	.0056	.0018	.50	.0100	.0000	3.2	-
8627	Mar. 15	Mar. 17	Decided.	Cons.	0.40	8.00	.0046	.0060	-	-	.54	.0100	.0001	2.5	-
8752	Apr. 18	Apr. 19	Slight.	Cons., fibrous.	0.30	7.80	.0044	.0072	.0050	.0022	.46	.0030	.0002	3.0	-
8898	May 16	May 17	Decided.	Heavy brown.	0.45	7.65	.0042	.0074	.0060	.0014	.46	.0020	.0000	2.7	-
8994	June 13	June 14	Slight.	Slight.	0.59	7.60	.0002	.0086	-	-	.55	.0050	.0001	2.5	-
9125	July 18	July 20	Decided, milky.	Cons.	0.55	8.60	.0036	.0092	-	-	.49	.0030	.0001	3.2	-
9249	Aug. 15	Aug. 16	Distinct, milky.	Slight.	0.40	8.25	.0020	.0060	-	-	.77	.0070	.0001	3.0	-
9394	Sept. 19	Sept. 20	Distinct, milky.	Cons., rusty.	0.70	10.05	.0028	.0080	-	-	.58	.0000	.0000	3.6	.1000 *.0068
9540	Oct. 17	Oct. 18	Decided, milky.	Cons., rusty.	0.45	9.90	.0044	.0064	.0030	.0034	.53	.0180	.0000	3.8	.2600 *.1300
9670	Nov. 14	Nov. 15	Distinct, milky.	Cons., yellow.	0.00	13.25	.0082	.0068	-	-	.52	.0120	.0000	5.0	.3900
9786	Dec. 12	Dec. 13	Decided, milky.	Cons.	0.80	9.90	.0050	.0116	.0102	.0014	.49	.0100	.0000	3.8	.1900
Av.	....	....	....	....	0.44	9.25	.0042	.0073	-	-	.54	.0071	.0001	3.4	.2350

Odor, generally disagreeable, occasionally mouldy, sometimes none; the odor is generally less strong on heating.—The first sample was collected from a faucet in the town; all others were collected from a faucet at the pumping station, generally while pumping.

NOTE.—The color of this water is due to the presence of Crenothrix or Zoöglœa and iron, and is generally determined without filtering the water. Owing to the excessive turbidity from these causes, the color of No. 9670 could not be determined from the unfiltered water, and the determination given was made with water that had been filtered through filter-paper.

* These determinations were made upon the water after filtration through filter-paper.

READING.

Microscopical Examination of Water from the Filter-Gallery of the Reading Water Works.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	18	19	20	17	14	20	16	21	18	15	14
Number of sample,	8426	8512	8627	8752	8898	8994	9125	9249	9394	9540	9670	9786
PLANTS.												
Diatomaceæ. Synedra,	21	0	2	0	0	1	0	1	0	0	0	0
Fungi. Crenothrix,	1	0	2,836	5,264	476	234	12,472	2,040	†	4,600	0	6,888
ANIMALS.												
Infusoria. Peridinium,	0	0	0	7	0	0	0	1	0	0	0	0
Miscellaneous. Zoöglœa,	98	1,584	9	8	0	3	0	0	0	0	248*	0
TOTAL,	120	1,584	2,847	5,279	476	238	12,472	2,042†	0	4,600	248	6,888

* Zoöglœa and iron rust.

† Crenothrix too fine and abundant to count.

Water Supply of Revere and Winthrop. — Revere Water Company.

The works at Saugus were enlarged in the summer of 1892 by driving 11 tubular wells, which were completed and first used September 3. The new wells were $2\frac{1}{2}$ inches in diameter and averaged 34.8 feet in depth, the longest being 47.4 feet, and the shortest 26 feet. The wells are in the immediate vicinity of those driven in previous years, and the total number of wells now connected with the works at Saugus is 23.

REVERE.

Chemical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8685	Mar. 29	Mar. 31	None.	V. slight.	0.02	11.20	.0000	.0000	0.98	.0120	.0002	5.9	–
8686	Mar. 29	Mar. 31	None.	V. slight.	0.00	11.25	.0000	.0000	0.99	.0100	.0002	5.6	–
8738	April 13	April 14	None.	None.	0.00	11.75	.0000	.0002	1.13	.0120	.0005	6.0	–
8916	May 14	May 19	V. slight, milky.	V. slight, earthy.	0.02	11.70	.0000	.0000	1.06	.0140	.0007	6.1	–
8986	June 7	June 9	Distinct, milky.	Cons., rusty.	0.05	11.90	.0000	.0008	1.30	.0090	.0014	5.7	–
9023	June 16	June 20	V. slight.	Slight.	0.03	11.45	.0000	.0018	1.30	.0050	.0010	6.0	–
9112	July 12	July 15	None.	None.	0.00	11.45	.0000	.0000	1.20	.0050	.0015	6.0	–
9234	Aug. 9	Aug. 11	None.	None.	0.00	12.00	.0000	.0006	1.53	.0120	.0030	6.3	.0230
9374	Sept. 14	Sept. 16	None.	None.	0.00	11.65	.0000	.0000	1.15	.0150	.0080	6.0	.0150
9522	Oct. 11	Oct. 13	None.	None.	0.00	11.95	.0000	.0000	1.09	.0150	.0130	6.3	.0060
9655	Nov. 7	Nov. 10	None.	None.	0.01	11.40	.0000	.0000	1.13	.0200	.0100	5.1	.0040
9776	Dec. 7	Dec. 10	None.	V. slight.	0.00	12.10	.0000	.0006	1.11	.0180	.0030	7.0	.0100
Av..	....	....	....	....	0.01	11.65	.0000	.0003	1.16	.0123	.0035	6.0	.0116

Odor of No. 8916, very faintly musty; of No. 9655, faintly disagreeable; of all others, none.—— The samples were collected from a faucet in the pumping station at Saugus. A new gang of tubular wells was connected with the pump, and used for the first time June 3, 1892.

Microscopical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.

[Number of organisms per cubic centimeter.]

	1892. Apr.	Apr.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	1	1	15	–	11	22	16	12	16	13	12	13
Number of sample,	8685	8686	8738	8916	8986	9023	9112	9234	9374	9522	9655	9776
PLANTS.												
Fungi. Crenothrix,	0	0	0	0	4,902	496	0	0	0	0	pr.	0
Miscellaneous. Zoöglœa,	0	0	0	110	70	60	0	0	0	0	20	0
Total,	0	0	0	110	4,972	556	0	0	0	0	20	0

Rockport.

Chemical Examination of Water from Cape Pond, Rockport.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9214	Aug. 8	Aug. 9	Distinct, green.	Cons., green.	0.15	12.05	2.55	.0000	.0250	.0150	.0100	5.24	.0030	.0001	1.4
9215	Aug. 8	Aug.10	Decided, green.	Cons., green.	0.15	11.70	2.30	.0004	.0318	.0210	.0108	5.40	.0000	.0000	1.3
9316	Aug.28	Aug.29	Distinct.	Cons., rusty.	0.12	12.45	2.50	.0096	.0186	.0128	.0058	5.20	.0050	.0000	0.9
9493	Oct. 3	Oct. 5	Slight.	Slight.	0.05	11.55	2.65	.0000	.0184	.0122	.0062	5.04	.0000	.0000	1.0
Av.	....	....	....	....	0.12	11.94	2.50	.0025	.0234	.0152	.0082	5.22	.0020	.0000	1.1

Odor of No. 9214, faintly vegetable; of the others, none; on heating, the odor of all samples was vegetable. —— The samples were collected from the pond near the centre, about one foot beneath the surface, with the exception of No. 9215, which was collected near the shore. There is a fish-glue factory upon the watershed of this pond, and the manufacturing wastes discharged from it affect very unfavorably the quality of the water.

Microscopical Examination of Water from Cape Pond, Rockport.

[Number of organisms per cubic centimeter.]

	1892. August.	1892. August.	1892. August.	1892. October.
Day of examination,	10	10	31	5
Number of sample,	9214	9215	9316	9493
PLANTS.				
Diatomaceæ,	**15**	**3**	**11**	**236**
Asterionella,	0	2	pr.	0
Diatoma,	1	0	1	61
Melosira,	9	0	10	27
Meridion,	0	0	0	3
Navicula,	1	1	pr.	1
Synedra,	4	0	pr.	144
Cyanophyceæ,	**25**	**17**	**0**	**0**
Anabæna,	25	14	0	0
Anabæna spores,	0	3	0	0
Algæ,	**271**	**418**	**27**	**132**
Chlorococcus,	2	0	2	6
Desmidium,	0	0	0	2
Nephrocytium,	3	13	0	4
Pediastrum,	1	pr.	3	4
Protococcus,	0	0	13	40
Raphidium,	4	0	7	0
Scenedesmus,	0	1	2	56
Selenastrum,	0	0	0	20
Sorastrum,	1	2	0	0
Tetraspora,	260	402	0	0
Fungi. Crenothrix,	**84**	**166**	**94**	**0**

ROCKPORT.

Microscopical Examination of Water from Cape Pond, Rockport — Concluded.

[Number of organisms per cubic centimeter.]

	1892.			
	August.	August.	August.	October.
ANIMALS.				
Rhizopoda. Difflugia,	0	0	pr.	0
Infusoria,	20	26	29	186
Glenodinium,	18	24	0	0
Peridinium,	0	0	26	180
Trachelomonas,	2	2	3	6
Vermes,	7	3	3	2
Anurea,	6	2	3	2
Monocerca,	1	1	0	0
Polyarthra,	0	0	pr.	0
Rotatorian ova,	0	pr.	0	0
Miscellaneous. Zoöglœa,	114	162	144	17
TOTAL,	536	795	308	573

WATER SUPPLY OF SALEM AND BEVERLY.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8398	Jan. 5	Jan. 6	V. slight.	Slight, green.	0.03	4.95	1.50	.0000	.0112	.0094	.0018	.72	.0100	.0000	1.7
8493	Feb. 9	Feb. 10	V. slight.	V. slight.	0.02	4.75	0.85	.0000	.0112	.0094	.0018	.75	.0050	.0001	1.9
8586	Mar. 8	Mar. 9	Slight.	Slight.	0.02	4.65	1.50	.0008	.0116	.0082	.0034	.77	.0070	.0000	1.8
8725	Apr. 12	Apr. 12	V. slight.	Slight.	0.03	4.60	1.30	.0000	.0146	.0106	.0040	.71	.0180	.0000	2.2
8878	May 10	May 11	Distinct.	Slight.	0.00	5.00	1.45	.0000	.0150	.0098	.0052	.72	.0180	.0000	1.9
8988	June 10	June 10	Slight.	Slight.	0.02	4.55	0.85	.0000	.0120	.0098	.0022	.79	.0000	.0000	2.0
9087	July 11	July 12	Slight.	Slight.	0.00	4.80	1.05	.0000	.0146	.0108	.0038	.77	.0050	.0000	2.1
9242	Aug. 12	Aug. 12	Distinct.	Slight.	0.10	4.85	0.70	.0000	.0170	.0114	.0056	.74	.0000	.0000	2.6
9387	Sept. 17	Sept. 17	Distinct.	Slight, gray.	0.02	5.25	1.00	.0000	.0108	.0088	.0020	.74	.0050	.0000	2.0
9506	Oct. 10	Oct. 11	Slight.	Slight.	0.05	5.10	0.85	.0086	.0136	.0096	.0040	.75	.0000	.0000	2.5
9647	Nov. 8	Nov. 9	Slight.	Cons., green.	0.02	5.10	1.00	.0096	.0146	.0130	.0016	.77	.0050	.0001	2.7
9775	Dec. 8	Dec. 9	Slight.	Slight.	0.02	4.65	1.20	.0000	.0182	.0132	.0050	.76	.0200	.0000	2.6
Av.	....	....	....	....	0.03	4.85	1.10	.0016	.0137	.0103	.0034	.75	.0077	.0000	2.2

Odor, vegetable, sometimes none; on heating, the odor is generally slightly stronger, and sometimes unpleasant. —— The samples were collected either from faucets at the Salem pumping station or directly from the lake over the inlet pipe. At the end of the year the lake was drawn lower than ever before. For heights of water at times when samples were collected for analysis, see page 228.

SALEM.

Microscopical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	10	10	13	11	11	12	13	17	12	10	9
Number of sample,	8398	8493	8586	8725	8878	8988	9087	9242	9387	9506	9647	9775
PLANTS.												
Diatomaceæ,	**658**	**237**	**374**	**749**	**600**	**79**	**54**	**514**	**555**	**520**	**1,993**	**2,145**
Asterionella,	270	26	4	11	22	40	10	27	104	3	452	604
Cyclotella,	94	94	180	368	468	16	22	0	6	29	72	144
Diatoma,	10	7	12	12	0	0	0	5	0	0	0	0
Fragilaria,	13	0	21	54	6	0	14	233	2	23	11	0
Melosira,	216	44	42	212	63	6	3	15	25	166	688	248
Navicula,	1	0	0	5	0	1	pr.	0	pr.	pr.	1	0
Stephanodiscus,	5	0	1	2	1	0	0	0	0	0	0	76
Synedra,	38	12	68	50	24	16	1	4	pr.	5	1	1
Tabellaria,	11	54	46	35	16	0	4	230	418	294	768	1,072
Cyanophyceæ,	**2**	**pr.**	**0**	**0**	**0**	**2**	**81**	**346**	**70**	**6**	**3**	**7**
Anabæna,	0	0	0	0	0	2	3	288	38	2	0	1
Chroöcoccus,	2	0	0	0	0	0	43	1	10	0	2	0
Clathrocystis,	0	0	0	0	0	0	pr.	22	1	0	0	0
Cœlosphærium,	0	0	0	0	0	0	1	35	18	2	1	6
Microcystis,	0	pr.	0	0	0	0	34	0	3	2	0	0
Algæ,	**4**	**8**	**1**	**19**	**14**	**3**	**28**	**4**	**48**	**31**	**6**	**52**
Botrycoccus,	0	0	0	0	0	0	0	1	pr.	8	0	0
Chlorococcus,	4	4	0	8	0	0	28	0	8	0	5	15
Hyalotheca,	0	4	1	7	14	0	0	0	0	0	0	0
Protococcus,	0	0	0	0	0	0	0	0	35	22	0	34
Scenedesmus,	0	pr.	0	1	0	3	0	0	pr.	1	1	0
Staurastrum,	pr.	0	0	3	0	0	0	3	5	pr.	0	3
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**0**
Actinophrys,	0	0	0	0	0	0	0	0	0	2	0	0
Difflugia,	0	0	0	0	0	1	0	0	0	pr.	0	0
Infusoria,	**6**	**pr.**	**2**	**200**	**180**	**25**	**pr.**	**10**	**21**	**63**	**138**	**257**
Ceratium,	0	0	0	0	0	0	0	1	pr.	0	0	0
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	24
Dinobryon,	0	0	0	88	40	24	0	0	0	39	85	111
Dinobryon cases,	0	0	2	112	140	0	0	0	0	6	36	14
Monas,	0	0	0	pr.	0	0	0	4	0	0	0	0
Peridinium,	0	0	0	pr.	0	0	0	0	18	0	0	0
Trachelomonas,	6	pr.	pr.	pr.	0	1	pr.	5	3	18	17	8
Vermes,	**0**	**0**	**0**	**pr.**	**0**	**1**	**pr.**	**0**	**1**	**pr.**	**0**	**0**
Anurea,	0	0	0	pr.	0	0	pr.	0	pr.	pr.	0	0
Polyarthra,	0	0	0	0	0	1	0	0	1	0	0	0
Miscellaneous. Zoöglœa,	**36**	**1**	**86**	**32**	**0**	**0**	**0**	**44**	**0**	**84**	**128**	**0**
TOTAL,	706	246	463	1,000	794	111	163	918	695	706	2,268	2,461

SALEM.

Table showing Heights of Water in Wenham Lake at Times when Samples of Water were collected for Analysis.

NOTE. — High-water mark is 30.17 feet.

Date.	Height of Water.	Date.	Height of Water.
1892.	Feet.	1892.	Feet.
Jan. 5,	25.3	July 11,	25.4
Feb. 9,	25.9	Aug. 12,	24.1
Mar. 8,	25.9	Sept. 17,	23.0
Apr. 12,	26.5	Oct. 10,	22.3
May 10,	26.1	Nov. 8,	21.5
June 10,	26.2	Dec. 8,	21.2

Water Supply of Saugus.

(See *Lynn*.)

Water Supply of Sharon. — Sharon Water Company.

Chemical Examination of Water from the Well of the Sharon Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8602	Mar. 9	Mar. 11	None.	None.	0.0	7.65	.0000	.0000	.92	.3000	.0000	2.9	–
9383	Sept. 15	Sept. 16	None.	None.	0.0	9.25	.0000	.0002	.96	.2000	.0000	3.0	.0000

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No organisms.

Water Supply of Somerville.

(See *Boston, Mystic Works.*)

WATER SUPPLY OF SOUTHBRIDGE. — SOUTHBRIDGE WATER COMPANY.

Chemical Examination of Water from the Upper Reservoir of the Southbridge Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8867	May 5	May 7	Distinct.	Slight.	0.08	2.95	1.00	.0000	.0132	.0086	.0046	.14	.0100	.0000	0.6
9244	Aug.15	Aug.16	Distinct.	Slight, rusty.	0.15	3.00	1.60	.0004	.0360	.0232	.0128	.18	.0050	.0000	1.1

Odor of first sample, faintly vegetable and unpleasant; of second sample, distinctly vegetable and mouldy. —— The samples were collected from the reservoir.

Microscopical Examination.

No. 8867. Diatomaceæ, *Asterionella*, 45; *Diatoma*, 3; *Navicula*, 2; *Synedra*, 44. Algæ, *Chlorococcus*, 6; *Cosmarium*, 3; *Microthamnion*, 1. Rhizopoda, *Difflugia*, 2. Infusoria, *Dinobryon cases*, 2; *Trachelomonas*, 1. Total, 109.

No. 9244. Diatomaceæ, *Asterionella*, 3; *Cyclotella*, 1,356; *Navicula*, 1; *Synedra*, 104. Algæ, *Chlorococcus*, 22; *Staurastrum*, 1; *Staurogenia*, 2. Infusoria, *Dinobryon cases*, 80; *Peridinium*, 1; *Trachelomonas*, 7. Miscellaneous, *Zoöglœa*, 240. Total, 1,817.

Chemical Examination of Water from the Lower Reservoir of the Southbridge Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8866	May 5	May 7	Distinct.	Slight.	0.10	3.15	1.15	.0014	.0174	.0132	.0042	.14	.0120	.0000	0.6
9245	Aug.15	Aug.16	Distinct.	Cons.	0.18	3.95	1.70	.0000	.0274	.0234	.0040	.18	.0030	.0001	1.9
9401	Sept.20	Sept.21	Distinct.	Slight.	0.23	3.60	1.25	.0000	.0254	.0202	.0052	.14	.0000	.0000	1.5
9699	Nov.21	Nov.22	Distinct.	Slight, yellow.	0.20	3.45	1.00	.0012	.0124	.0084	.0040	.18	.0120	.0000	1.9
Av.	....	....	....	....	0.18	3.54	1.27	.0006	.0206	.0163	.0043	.16	.0067	.0000	1.5

Odor, vegetable and unpleasant. —— The samples were collected from the reservoir, excepting the last, which was collected from a faucet in the town.

SOUTHBRIDGE.

Microscopical Examination of Water from the Lower Reservoir of the Southbridge Water Company.

[Number of organisms per cubic centimeter.]

	1892.			
	May.	Aug.	Sept.	Nov.
Day of examination,	7	16	21	22
Number of sample,	8866	9245	9401	9699
PLANTS.				
Diatomaceæ,	290	655	142	311
Asterionella,	12	4	0	192
Diatoma,	13	0	0	pr.
Melosira,	3	0	0	0
Navicula,	4	1	0	3
Synedra,	246	650	142	116
Tabellaria,	12	0	0	0
Algæ,	1	5	pr.	1
Chlorococcus,	pr.	2	0	0
Cosmarium,	0	3	pr.	0
Scenedesmus,	1	pr.	pr.	1
Fungi. Crenothrix,	1	0	0	7
ANIMALS.				
Rhizopoda. Difflugia,	3	0	pr.	pr.
Infusoria,	7	441	42	8
Codonella,	0	0	pr.	0
Dinobryon,	0	0	0	3
Dinobryon cases,	0	268	0	0
Monas,	1	0	4	0
Peridinium,	3	172	38	5
Phacus,	0	0	pr.	0
Prorodon,	3	0	0	0
Trachelomonas,	0	1	0	0
Vermes,	9	1	pr.	pr.
Anurea,	9	0	pr.	0
Asplanchna,	0	0	pr.	0
Monocerca,	0	1	0	0
Polyarthra,	0	pr.	pr.	0
Rotifer,	0	0	0	pr.
Miscellaneous. Zoöglœa,	60	160	60	94
Total,	371	1,262	244	421

SOUTH HADLEY.

Water Supply of South Hadley Falls Fire District, South Hadley.

Chemical Examination of Water from Faucets in South Hadley, supplied from Buttery Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9158	July 27	July 28	Slight.	Slight.	0.18	3.75	1.00	.0000	.0088	.0064	.0024	.15	.0000	.0000	1.1
9409	Sept.20	Sept.21	Distinct	Cons., green.	0.15	3.10	1.10	.0004	.0296	.0202	.0094	.09	.0000	.0000	0.9

Odor, distinctly vegetable, and in the first sample unpleasant.

Microscopical Examination.

No. 9158. Diatomaceæ, *Navicula*, 1. Algæ, *Desmidium*, 13. Fungi, *Crenothrix*, 6. Infusoria, *Dinobryon cases*, 1; *Trachelomonas*, 1. Crustacea, *Bosmina*, 01. Miscellaneous, *Zoōglœa*, 84. Total, 106.

No. 9409. Diatomaceæ, *Cyclotella*, 1; *Synedra*, 4. Algæ, *Botrycoccus*, 1; *Raphidium*, 14; *Scenedesmus*, 2; *Staurastrum*, 1; *Zoōspores*, 1. Fungi, *Crenothrix*, 3. Infusoria, *Euglena*, 1; *Peridinium*, 5. Vermes, *Polyarthra*, 1. Miscellaneous, *Zoōglœa*, 360. Total, 394.

Chemical Examination of Water from the Leaping Well Reservoir, South Hadley.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8476	Jan. 30	Feb. 2	None.	V.slight.	0.05	2.95	0.50	.0008	.0058	.0028	.0030	.14	.0400	.0000	0.9
8510	Feb. 13	Feb. 16	V.slight.	V.slight.	0.15	3.35	1.00	.0026	.0122	.0094	.0028	.15	.0280	.0000	1.8
8665	Mar. 24	Mar. 25	V slight.	V.slight.	0.05	2.90	0.55	.0004	.0116	.0074	.0042	.14	.0050	.0001	0.9
8808	Apr. 25	Apr. 27	Distinct.	Cons., rusty.	0.15	3.70	1.15	.0018	.0290	.0174	.0116	.13	.0120	.0000	1.1
8906	May 17	May 18	Slight.	Slight, green.	0.10	4.30	2.00	.0004	.0120	.0092	.0028	.10	.0030	.0001	0.8
8951	May 31	June 1	Slight.	Cons., green.	0.05	2.90	0.60	.0002	.0124	.0098	.0026	.13	.0020	.0000	1.1
9018	June 16	June 18	Slight.	Slight.	0.10	3.50	1.00	.0030	.0146	.0116	.0030	.16	.0070	.0001	0.5
9227	Aug. 9	Aug. 11	Distinct.	Slight, rusty.	0.28	4.10	1.90	.0112	.0316	.0260	.0056	.09	.0000	.0000	1.7
9297	Aug. 23	Aug. 25	Slight.	Cons., rusty.	0.48	4.20	2.00	.0026	.0336	.0262	.0074	.10	.0030	.0001	1.3
9465	Sept. 27	Sept. 29	Slight.	Slight, green.	0.12	3.15	1.10	.0000	.0196	.0170	.0026	.07	.0030	.0001	1.0
9557	Oct. 21	Oct. 22	Slight.	V.slight.	0.03	3.60	0.40	.0006	.0012	.0010	.0002	.12	.0200	.0000	0.8
9751	Dec. 1	Dec. 2	Slight.	V.slight.	0.20	3.00	1.00	.0006	.0224	.0188	.0036	.10	.0030	.0000	1.7
9782	Dec. 12	Dec. 13	V.slight.	V.slight.	0.20	2.80	1.00	.0000	.0168	.0132	.0036	.08	.0070	.0000	1.4
Av.	....	....	....	....	0.16	3.40	1.08	.0020	.0175	.0134	.0041	.12	.0109	.0000	1.2

Odor, vegetable, frequently mouldy or unpleasant, sometimes none. —— The samples were collected from the reservoir. The reservoir began to fill for the first time Jan. 16, 1892, and the surface of the water was within nine feet of the overflow on January 30. It was drawn down quite low toward the end of April, in order that repairs might be made on the dam, but was overflowing about the middle of August.

SOUTH HADLEY.

Microscopical Examination of Water from Leaping Well Reservoir, South Hadley.

[Number of organisms per cubic centimeter.]

	1892.												
	Feb.	Feb.	Mar.	Apr.	May.	June.	June.	Aug.	Aug.	Sept.	Oct.	Dec.	Dec.
Day of examination, . . .	3	18	26	29	19	2	18	12	25	30	24	3	14
Number of sample, . . .	8476	8510	8665	8808	8906	8951	9018	9227	9297	9465	9557	9751	9782
PLANTS.													
Diatomaceæ, . . .	**3**	**2**	**pr.**	**3**	**54**	**61**	**13**	**2**	**0**	**0**	**1**	**0**	**1**
Melosira, ...	0	0	0	0	0	1	13	0	0	0	0	0	0
Synedra, ...	3	2	pr.	3	54	60	0	2	0	0	1	0	1
Cyanophyceæ. Anabæna,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**72**	**0**	**0**	**0**	**0**
Algæ, ...	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**55**	**118**	**25**	**0**	**0**	**0**
Chlorococcus, . . .	0	0	0	0	0	0	0	55	20	25	0	0	0
Dictyosphærium, . .	0	0	0	0	0	0	0	0	98	0	0	0	0
Fungi. Crenothrix, . .	**18**	**0**	**0**	**8**	**0**	**0**	**1**	**52**	**172**	**3**	**22**	**5**	**0**
ANIMALS.													
Infusoria, ...	**0**	**0**	**1,087**	**0**	**358**	**214**	**0**	**3**	**10**	**0**	**0**	**39**	**45**
Dinobryon, ...	0	0	600	0	312	0	0	0	0	0	0	12	0
Dinobryon cases, . .	0	0	472	0	46	214	0	0	10	0	0	0	13
Peridinium, . . .	0	0	15	0	0	0	0	0	0	0	0	1	0
Rhipidodendron, . .	0	0	0	0	0	0	0	3	0	0	0	0	0
Disintegrated infusoria, .	0	0	0	0	0	0	0	0	0	0	0	26	32
Vermes, ...	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**71**	**0**	**0**	**1**	**pr.**
Polyarthra, ...	0	0	0	0	0	0	0	0	2	0	0	0	pr.
Rotatorian ova, . . .	0	0	0	0	0	0	0	0	1	0	0	1	pr.
Sacculus, ...	0	0	0	0	0	0	0	0	68	0	0	0	0
Miscellaneous. Zoöglœa, .	**8**	**10**	**62**	**400**	**52**	**360**	**0**	**152**	**0**	**pr.**	**100**	**0**	**0**
Total, ...	29	12	1,149	411	464	635	14	268	443	28	123	45	46

Water Supply of Spencer.

Chemical Examination of Water from Shaw Pond, Leicester.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8638	Mar. 17	Mar. 18	V. slight.	V. slight.	0.0	2.30	0.85	.0000	.0122	.0106	.0016	0.18	.0100	.0000	0.6

Odor, faintly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 1.

Water Supply of Springfield.

Chemical Examination of Water from the Receiving Basin of the Springfield Water Works at Ludlow.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8411	Jan. 11	Jan. 12	V. slight.	Slight.	0.50	3.95	1.45	.0000	.0090	.0076	.0014	.12	.0150	.0000	0.9
8502	Feb. 10	Feb. 11	Slight.	Cons.	0.25	3.75	1.10	.0000	.0092	.0058	.0034	.13	.0090	.0001	0.9
8604	Mar. 9	Mar. 11	Distinct.	Cons.	0.40	3.00	1.40	.0000	.0172	.0146	.0026	.15	.0100	.0000	0.8
8728	Apr. 12	Apr. 13	V. slight.	Cons., earthy.	0.20	3.15	1.00	.0008	.0180	.0150	.0030	.16	.0070	.0000	0.9
8879	May 10	May 11	Distinct.	Cons.	0.40	3.35	1.25	.0012	.0158	.0120	.0038	.12	.0150	.0000	1.3
8982	June 8	June 9	Slight.	Cons.	0.50	3.65	1.50	.0000	.0188	.0158	.0030	.14	.0050	.0001	1.1
9094	July 12	July 13	Slight.	Cons., green.	0.35	3.80	1.35	.0000	.0184	.0138	.0046	.14	.0000	.0000	1.6
9218	Aug. 9	Aug. 10	Slight.	Cons.	0.50	4.45	1.75	.0024	.0240	.0178	.0062	.15	.0090	.0002	1.8
9365	Sept. 13	Sept. 14	Slight.	Cons.	0.45	4.10	1.60	.0000	.0176	.0138	.0038	.12	.0050	.0003	1.3
9519	Oct. 11	Oct. 12	Slight.	Slight.	0.70	4.25	1.55	.0000	.0200	.0142	.0058	.13	.0150	.0001	1.7
9691	Nov. 17	Nov. 19	Slight.	Slight.	0.70	4.00	1.65	.0000	.0160	.0126	.0034	.12	.0100	.0000	1.5
9760	Dec. 5	Dec. 6	V. slight.	V. slight.	0.35	4.05	1.05	.0000	.0130	.0094	.0036	.14	.0070	.0000	1.8
Av.	....	....	....	....	0.44	3.79	1.39	.0004	.0164	.0127	.0037	.14	.0089	.0001	1.3

Odor, generally faintly vegetable or grassy, seldom unpleasant, sometimes none; on heating, the odor is generally stronger. —— The samples were collected from the basin at the gate-house. This basin originally formed a part of Ludlow Reservoir, but is now separated from the main reservoir by a dam.

SPRINGFIELD.

Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	12	11	14	12	10	13	10	14	13	21	7
Number of sample,	8411	8502	8604	8728	8879	8982	9094	9218	9365	9519	9691	9760
PLANTS.												
Diatomaceæ,	**82**	**6**	**6**	**83**	**324**	**245**	**195**	**232**	**39**	**71**	**62**	**42**
Amphora,	0	0	0	pr.	0	2	6	0	0	1	0	0
Asterionella,	72	0	0	0	4	4	11	0	9	16	12	15
Cocconema,	0	0	0	pr.	0	2	2	2	0	0	0	0
Cyclotella,	0	0	0	1	1	1	60	4	2	3	0	0
Cymbella,	0	2	pr.	26	60	14	25	16	0	8	0	0
Diatoma,	2	0	0	3	3	2	2	2	0	0	0	1
Fragilaria,	0	0	2	2	0	19	7	4	0	2	9	0
Melosira,	0	4	1	13	72	115	53	80	24	18	34	7
Meridion,	0	pr.	0	3	4	6	3	0	0	0	0	0
Navicula,	0	pr.	pr.	17	88	19	10	112	2	8	6	5
Surirella,	0	0	0	2	3	3	1	0	1	0	0	0
Synedra,	8	pr.	3	14	88	36	14	10	1	14	1	7
Tabellaria,	0	0	0	2	1	22	1	2	0	1	0	7
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**12**	**17**	**2**	**0**	**0**	**0**	**0**
Anabæna,	0	0	0	0	0	0	8	2	0	0	0	0
Chroöcoccus,	0	0	0	0	0	12	0	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	9	0	0	0	0	0
Algæ,	**2**	**pr.**	**25**	**1**	**3**	**3**	**23**	**8**	**3**	**9**	**0**	**4**
Chlorococcus,	0	0	0	0	0	0	11	0	0	9	0	0
Cœlastrum,	0	0	25	0	0	0	1	0	0	0	0	0
Pediastrum,	0	0	0	0	0	1	3	2	1	0	0	0
Raphidium,	2	0	0	0	0	0	0	0	0	0	0	4
Scenedesmus,	0	0	0	1	2	2	5	4	2	0	0	0
Staurastrum,	pr.	pr.	0	0	1	0	3	2	0	0	0	0
Fungi,	**15**	**3**	**84**	**3**	**14**	**1**	**0**	**0**	**0**	**40**	**3**	**5**
Crenothrix,	15	3	84	3	14	1	0	0	0	2	3	4
Molds,	0	0	0	0	0	0	0	0	0	38	0	1
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**	**1**	**0**
Actinophrys,	0	0	0	0	0	0	0	2	1	1	0	0
Arcella,	0	0	0	0	0	0	0	0	1	0	1	0
Infusoria,	**2**	**1**	**1**	**16**	**21**	**67**	**104**	**6**	**4**	**13**	**1**	**0**
Dinobryon,	1	0	1	11	6	0	0	0	0	0	0	0
Dinobryon cases,	0	0	pr.	0	14	0	100	2	1	5	0	0
Euglena,	0	0	0	0	0	64	2	0	0	0	0	0
Gonium,	0	0	0	pr.	1	0	0	0	0	0	0	0
Monas,	pr.	0	0	pr.	0	0	0	0	0	0	1	0
Peridinium,	1	1	0	5	0	2	0	2	0	7	0	0
Trachelomonas,	0	0	pr.	pr.	0	1	2	2	3	1	0	0

SPRINGFIELD.

Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow — Concluded.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS — Con.												
Vermes, ...	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**5**	**6**	**1**	**0**	**0**
Conochilus, ...	0	0	0	0	0	0	2	3	1	0	0	0
Polyarthra, ...	0	0	0	0	0	1	0	2	3	1	0	0
Rotatorian ova, . . .	0	0	0	0	0	0	0	0	2	0	0	0
Miscellaneous. Zoöglœa, .	**70**	**66**	**232**	**3**	**136**	**22**	**68**	**328**	**0**	**188**	**80**	**4**
TOTAL, ...	171	76	348	106	498	351	409	583	54	323	147	55

*Chemical Examination of Water from Ludlow Reservoir.**

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8412	Jan. 11	Jan. 12	Slight.	Cons.	0.20	3.85	1.75	.0000	.0238	.0214	.0024	.13	.0050	.0000	0.8
8503	Feb. 10	Feb. 11	Slight.	Slight.	0.25	3.05	1.05	.0012	.0172	.0132	.0040	.13	.0060	.0001	0.8
8605	Mar. 9	Mar. 11	Slight.	Slight.	0.25	3.05	1.35	.0014	.0196	.0152	.0044	.14	.0070	.0000	0.9
8729	Apr. 12	Apr. 13	Slight.	Cons., green.	0.20	2.90	0.90	.0000	.0252	.0192	.0060	.14	.0060	.0000	1.1
8880	May 10	May 11	Distinct.	Cons., green.	0.20	3.15	1.60	.0000	.0244	.0158	.0086	.12	.0050	.0000	0.6
8983	June 8	June 9	Distinct, milky.	Cons., yellow.	0.25	3.70	1.65	.0018	.0340	.0246	.0094	.14	.0030	.0001	1.1
9093	July 12	July 13	Distinct.	Cons., green.	0.25	3.30	1.55	.0000	.0478	.0240	.0238	.11	.0000	.0000	1.1
9217	Aug. 9	Aug. 10	Distinct.	Cons., green.	0.20	3.75	1.60	.0008	.0414	.0238	.0176	.12	.0070	.0002	1.5
9366	Sept. 13	Sept. 14	Slight.	Cons.	0.45	3.90	1.25	.0000	.0160	.0130	.0030	.11	.0050	.0005	1.3
Av.	....	....	....	....	0.25	3.41	1.41	.0006	.0277	.0189	.0088	.13	.0049	.0001	1.0

Odor in June and July, decidedly vegetable and grassy and somewhat unpleasant; in the other months, generally faintly vegetable and occasionally unpleasant. On heating, the odor was strongly vegetable and grassy, excepting in January, February and September, when it was faintly vegetable. —— The first and last samples were collected from the reservoir near the Cherry Valley gate-house; Nos. 8503 to 8880 were collected from near the cut-off dam separating the reservoir from the receiving basin; the remaining samples were collected from near the centre of the reservoir. The samples were collected from one to five feet beneath the surface, with the exception of Nos. 8880 and 8983, which were collected ten and fifteen feet respectively beneath the surface. This reservoir was emptied during the latter part of the year. For height of water at times when samples were collected for analysis, see page 237.

* This reservoir was not used as a source of water supply in 1892.

SPRINGFIELD.

Microscopical Examination of Water from Ludlow Reservoir.

[Number of organisms per cubic centimeter.]

	1892.								
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Day of examination,	13	12	11	14	12	10	13	10	14
Number of sample,	8412	8503	8605	8729	8880	8983	9093	9217	9366
PLANTS.									
Diatomaceæ,	**113**	**205**	**241**	**693**	**2,942**	**636**	**33**	**640**	**126**
Asterionella,	72	78	60	37	500	572	28	120	40
Cyclotella,	0	pr.	pr.	3	176	3	0	2	1
Cymbella,	0	0	0	7	0	0	0	0	1
Diatoma,	2	0	0	7	2	0	0	2	0
Fragilaria,	0	0	0	0	18	0	0	0	6
Melosira,	0	13	17	632	1,824	28	0	436	63
Navicula,	0	pr.	0	1	0	1	0	0	10
Synedra,	8	108	164	6	416	8	0	80	4
Tabellaria,	31	6	0	0	6	24	5	0	1
Cyanophyceæ,	**0**	**26**	**2**	**104**	**106**	**102**	**864**	**130**	**0**
Anabæna,	0	0	0	0	4	25	48	4	0
Aphanocapsa,	0	0	0	0	0	1	36	0	0
Chroöcoccus,	0	23	2	76	16	0	0	0	0
Clathrocystis,	0	2	0	7	2	0	4	88	0
Cœlosphærium,	0	1	0	21	84	76	776	38	0
Algæ,	**2**	**45**	**278**	**34**	**211**	**39**	**99**	**26**	**26**
Chlorococcus,	0	pr.	16	0	8	0	0	0	0
Closterium,	0	1	26	0	0	10	3	4	0
Cosmarium,	0	0	0	0	0	0	0	0	5
Dictyosphærium,	0	0	0	0	16	0	0	0	0
Pediastrum,	0	0	0	0	3	0	0	4	1
Protococcus,	0	0	0	0	0	0	48	0	12
Raphidium,	2	3	174	4	168	12	0	0	0
Scenedesmus,	0	36	34	30	9	13	36	6	8
Staurastrum,	pr.	0	pr.	0	3	4	12	12	0
Staurogenia,	0	5	28	0	4	0	0	0	0
Fungi. Crenothrix,	**0**	**0**	**96**	**0**	**0**	**0**	**0**	**0**	**1**
ANIMALS.									
Rhizopoda,	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**6**	**1**
Actinophrys,	0	0	8	0	0	0	0	2	1
Difflugia,	0	0	0	0	0	0	0	4	0
Infusoria,	**pr.**	**7**	**200**	**400**	**130**	**1**	**0**	**8**	**40**
Codonella,	0	pr.	2	0	0	0	0	0	0
Cryptomonas,	0	0	0	11	0	0	0	0	0
Dinobryon,	0	4	96	164	9	0	0	0	40
Dinobryon cases,	0	0	102	196	4	0	0	0	0
Gonium,	0	0	0	2	0	0	0	0	0
Monas,	pr.	pr.	0	2	0	0	0	0	0
Peridinium,	pr.	3	pr.	22	112	0	0	0	0
Synura,	0	0	0	3	4	0	0	0	0
Trachelomonas,	0	0	0	0	1	1	0	8	0
Vermes,	**1**	**pr.**	**0**	**0**	**2**	**2**	**1**	**28**	**4**
Anurea,	1	pr.	0	0	0	2	0	16	1
Polyarthra,	0	0	0	0	0	0	0	2	2
Rotatorian ova,	0	0	0	0	0	0	0	4	0
Rotifer,	0	0	0	0	0	0	1	4	1
Sacculus,	0	0	0	0	2	0	0	2	0
Miscellaneous. Zoöglœa,	**56**	**64**	**68**	**11**	**172**	**244**	**0**	**312**	**0**
TOTAL,	172	347	893	1,242	3,563	1,024	997	1,150	198

SPRINGFIELD.

Table showing Heights of Water in Ludlow Reservoir at Times when Samples of Water were collected for Analysis.

NOTE. — Height of rollway, 23.00 feet.

DATE.	Height of Water.	DATE.	Height of Water.
1892.	Feet.	1892.	Feet.
Jan. 11,	16.80	June 8,	18.10
Feb. 10,	17.90	July 12,	17.12
Mar. 9,	18.50	Aug. 9,	17.70
April 12,	17.90	Sept. 13,	16.96
May 10,	18.25		

NOTE. — At the end of the year the reservoir was empty.

Chemical Examination of Water from Van Horn Reservoir, Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
9651	Nov. 9	Nov. 10	Distinct.	Slight, brown.	0.15	3.50	0.85	.0000	.0320	.0266	.0054	.17	.0000	.0000	2.1

Odor, distinctly vegetable and disagreeable. —— The sample was collected from the reservoir, near the middle, one foot beneath the surface.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 17; *Melosira*, 126; *Navicula*, 1; *Synedra*, 1. Algæ, *Hyalotheca*, 2. Vermes, *Anurea*, 1. Miscellaneous, *Zoöglœa*, 46. Total, 194.

WATER SUPPLY OF STOCKBRIDGE. — STOCKBRIDGE WATER COMPANY.

Works for the introduction of a supply of water from Lake Averic were completed in 1892. The lake is situated in the northerly part of the town of Stockbridge, and covers an area of about fifty acres. Its watershed, of 1.75 square miles, including the area of the lake, consists of mountainous territory free from population. Water is taken from the lake at a point about 10.5 feet below high-water mark, and flows by gravity to the village. The lake is at a sufficient elevation to supply water to the village for domestic uses by gravity, but a pumping plant is provided to furnish greater pressure in case of fire.

STOCKBRIDGE.

The deep tubular well on the side of Bear Mountain, from which a portion of the water supply was formerly drawn, has been abandoned, but the small reservoir near by is still used when it will furnish sufficient water to supply the village. At times of low flow it is shut off from the village and is used as a high-service supply for a few houses, its elevation being about ten feet greater than that of Lake Averic. The distributing mains are of cast iron; service pipes are of galvanized iron.

Water Supply of Stoneham.

(See *Wakefield.*)

Water Supply of Stoughton.

The works of the Stoughton Water Company were purchased by the town in June, 1892.

The advice of the State Board of Health to the water commissioners of the town of Stoughton with reference to a new source of water supply may be found on page 45 of this report. Works for the introduction of a new supply have been begun.

*Chemical Examination of Water from the Well of the Stoughton Water Works.**

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8557	Feb. 24	Feb. 26	None.	V. slight.	0.0	17.80	.0028	.0044	2.96	1.1000	.0005	6.7	-
8844	May 3	May 4	None.	None.	0.0	19.80	.0018	.0030	2.68	1.0000	.0005	6.3	-
9022	June 19	June 20	None.	None	0.0	19.30	.0000	.0040	2.66	0.8000	.0000	5.7	-
9389	Sept. 19	Sept. 19	None.	None.	0.0	17.25	.0000	.0026	2.22	0.5500	.0000	6.4	.0050
9728	Nov. 28	Nov. 28	None.	None.	0.0	21.40	.0002	.0024	2.93	0.8000	.0000	8.0	.0050
Av.	....	....	....	....	0.0	19.11	.0010	.0033	2.69	0.8500	.0002	6.6	-

Odor, generally none, occasionally faint.——The samples were collected from faucets in the town.

Microscopical Examination.

No. 8557. Miscellaneous, *Zoöglœa*, 64; *iron rust*, 4.
In the remaining samples no organisms were found.

* This well was the source of supply used by the Stoughton Water Company. The use of water from this source will be discontinued when the new works, now being constructed by the town, are completed.

STOUGHTON.

Chemical Examination of Water from Sources near Muddy Pond and Knowles' Brook, Stoughton.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8746	Apr. 18	Apr. 19	V. slight.	Slight.	0.12	3.10	0.90	.0002	.0050	.0044	.0006	.31	.0020	.0000	0.6
8747	Apr. 18	Apr. 19	None.	None.	0.00	5.05	-	.0002	.0006	-	-	.36	.0100	.0000	2.1
8748	Apr. 18	Apr. 19	None.	None.	0.00	2.40	-	.0000	.0000	-	-	.35	.0020	.0000	0.5

Odor of the first sample, vegetable and unpleasant; of the others, none.——The first sample was collected from Muddy Pond Brook, about half a mile above the point where it crosses Elm Street; the second sample, from the tubular test well located a short distance from the brook in the locality just mentioned; the third sample was collected from a spring on the westerly shore of a small pond on Knowles' Brook, a short distance above Central Street. The samples were collected during an investigation for a new water supply for Stoughton.

Microscopical Examination.

Only an insignificant number of organisms was found in these samples.

Water Supply of Swampscott and Nahant. — Marblehead Water Company.

The capacity of these works was increased about July 1, 1892, by the introduction of an additional supply from a system of 26 tubular wells located in Paradise Road, north-easterly from the pumping station. The wells are two and a half inches in diameter and from forty-three to fifty-seven feet in depth, passing down through about thirty-eight feet of clay and a stratum of gravel to rock. The wells are from forty-two to fifty-two feet apart; the nearest one is 1,458 feet from the pumping station, and the farthest one 2,650 feet.

Water flows by gravity from the tubular wells through a ten-inch pipe laid seven feet beneath the surface in Paradise Road to the large well at the pumping station.

SWAMPSCOTT.

Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8431	Jan. 18	Jan. 19	None.	None.	0.0	49.40	.0000	.0020	11.82	.9000	.0000	24.5	-
8498	Feb. 9	Feb. 10	None.	None.	0.0	49.95	.0000	.0010	12.01	1.0000	.0001	24.2	-
8585	Mar. 7	Mar. 8	None.	None.	0.0	56.30	.0000	.0016	14.15	1.1000	.0000	23.0	-
8724	Apr. 11	Apr. 12	None.	None.	0.0	53.95	.0000	.0012	15.39	1.0000	.0000	26.3	-
8874	May 9	May 10	None.	None.	0.0	53.20	.0000	.0014	17.62	.8500	.0000	39.7	-
8979	June 8	June 9	V. slight.	V. slight.	0.0	49.30	.0000	.0024	13.20	.3750	.0001	12.4	-
9100	July 11	July 13	None.	None.	0.0	52.20	.0000	.0000	13.10	.7500	.0000	22.2	-
9213	Aug. 8	Aug. 9	Slight.	V. slight.	0.0	59.75	.0000	.0010	14.00	.7500	.0000	24.4	.0108
9433	Sept. 23	Sept. 24	None.	Slight.	0.0	70.95	.0000	.0004	19.74	.8000	.0000	14.0	.0060
9507	Oct. 10	Oct. 11	None.	None.	0.0	67.70	.0000	.0000	17.62	.6000	.0001	19.4	.0040
9657	Nov. 9	Nov. 10	None.	None.	0.0	62.20	.0000	.0008	16.82	.3500	.0000	-	.0040
9770	Dec. 8	Dec. 8	None.	None.	0.0	34.40	.0000	.0000	8.90	.4500	.0000	11.6	.0120
Av.	....	....	....	....	0.0	54.94	.0000	.0010	14.53	.7437	.0000	22.0	.0074

Odor, none.—The samples were collected from a faucet at the pumping station. After about the 10th of August the supply was drawn wholly from the large well and the tubular wells in Paradise road, the other tubular wells being shut off.

Microscopical Examination.

Occasionally an insignificant number of organisms was found in this water, but generally none.

Chemical Examination of Water from Wells of the Marblehead Water Company on Paradise Road, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9361	Sept. 12	Sept. 13	None.	None.	0.0	12.00	.0004	.0004	.91	.0150	.0000	6.1	.0035

Odor, none.—The samples were collected from a tap on the temporary pump, while pumping from twenty-six wells.

Microscopical Examination.

No organisms.

Water Supply of Taunton.

Chemical Examination of Water from the Filter-Basin of the Taunton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8451	Jan. 26	Jan. 27	V.slight.	Slight.	0.28	5.50	0.90	.0000	.0042	-	-	.60	.0150	.0000	1.7
8553	Feb. 25	Feb. 26	Slight.	Cons., brown.	0.40	5.25	1.30	.0020	.0118	.0094	.0024	.59	.0220	.0001	1.0
8678	Mar. 28	Mar. 28	V.slight	Cons.	0.55	4.55	1.35	.0000	.0106	.0084	.0022	.50	.0070	.0000	1.3
8824	Apr. 28	Apr. 29	V.slight.	Slight.	0.55	5.40	1.70	.0000	.0090	.0080	.0010	.61	.0150	.0000	1.4
8939	May 26	May 26	V.slight.	Slight.	0.90	5.85	2.10	.0006	.0150	.0110	.0040	.56	.0070	.0000	1.6
9067	July 2	July 2	None.	V.slight.	0.60	5.55	1.90	.0010	.0122	-	-	.49	.0150	.0001	1.6
9149	July 27	July 27	V.slight.	V.slight	0.90	5.65	2.15	.0000	.0182	-	-	.55	.0070	.0002	1.7
9296	Aug. 24	Aug. 24	V.slight.	V.slight.	0.70	6.20	2.10	.0002	.0112	-	-	.61	.0030	.0001	2.0
9472	Sept. 29	Sept. 30	V.slight.	V.slight.	0.50	5.35	1.65	.0000	.0104	-	-	.64	.0200	.0004	1.7
9575	Oct. 26	Oct 27	None.	V.slight.	0.30	4.90	1.05	.0000	.0082	-	-	.61	.0180	.0000	1.6
9741	Nov. 29	Nov. 30	V.slight	Slight.	1.00	6.45	2.05	.0012	.0190	.0174	.0016	.65	.0200	.0002	2.1
9813	Dec. 20	Dec. 21	V.slight.	V.slight.	0.55	5.75	1.60	.0016	.0188	-	-	.60	.0280	.0001	1.6
Av.	....	....	....	....	0.60	5.53	1.65	.0005	.0124	-	-	.58	.0147	.0001	1.6

Odor, generally distinctly vegetable, frequently grassy and occasionally mouldy. —— The samples were collected from a faucet at the pumping station while pumping. Water from the Taunton River is admitted directly to the filter-basin whenever the yield of the latter is insufficient for the supply of the city.

Microscopical Examination of Water from the Filter-Basin of the Taunton Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	July.	July.	Aug.	Sept.	Oct.	Dec.	Dec.
Day of examination, . . .	27	26	30	30	26	2	28	25	30	27	1	21
Number of sample, . . .	8451	8553	8678	8824	8939	9067	9149	9296	9472	9575	9741	9813
PLANTS.												
Diatomaceæ, . . .	7	250	16	9	0	pr.	8	26	9	8	5	pr.
Asterionella, . . .	0	6	0	0	0	0	0	0	0	1	0	0
Diatoma, ...	pr.	9	1	2	0	0	0	6	0	0	0	0
Fragilaria, ...	0	6	0	1	0	0	4	1	0	0	0	0
Melosira, ...	0	1	11	0	0	0	2	18	9	4	3	0
Navicula, ...	2	2	1	5	0	pr.	2	pr.	0	3	2	0
Synedra, ...	5	226	3	1	0	pr.	0	1	0	0	0	pr.
Cyanophyceæ. Oscillaria,	1	0	4	4	0	1	pr.	pr.	1	6	0	0
Algæ. Sphærozosma, . .	0	0	0	0	15	0	0	0	0	0	0	0
Fungi. Crenothrix, . .	234	3	90	3	0	2	58	7	7	0	5	0

TAUNTON.

Microscopical Examination of Water from the Filter-Basin of the Taunton Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	July.	July.	Aug.	Sept.	Oct.	Dec.	Dec.
ANIMALS.												
Infusoria,	**0**	**0**	**1**	**0**	**0**	**0**	**7**	**pr.**	**0**	**0**	**1**	**7**
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	4
Peridinium,	0	0	0	0	0	0	7	pr.	0	0	1	1
Synura,	0	0	1	0	0	0	0	0	0	0	0	2
Miscellaneous. Zoöglœa,	**0**	**84**	**58**	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL,	242	337	169	18	15	5	73	33	17	14	11	7

Chemical Examination of Water from the Taunton River at Taunton.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8450	Jan. 26	Jan. 27	Distinct.	Cons.	1.00	4.80	2.45	.0000	.0190	.0160	.0030	.48	.0100	.0000	1.3
8552	Feb. 25	Feb. 26	Distinct.	Cons.	0.90	4.95	1.65	.0024	.0204	.0186	.0018	.51	.0100	.0002	0.8
8677	Mar. 28	Mar. 28	Slight.	Slight.	1.00	4.35	1.70	.0012	.0190	.0180	.0010	.44	.0090	.0000	0.5
8823	Apr. 28	Apr. 29	Slight.	Slight.	1.00	4.40	2.10	.0006	.0212	.0188	.0024	.51	.0100	.0000	1.1
8938	May 26	May 26	V. slight.	Cons.	1.70	5.55	3.00	.0006	.0282	.0246	.0036	.41	.0050	.0001	0.6
9066	July 2	July 2	V. slight.	Slight.	1.65	5.40	2.60	.0044	.0274	.0262	.0012	.42	.0090	.0000	1.0
9148	July 27	July 27	V. slight.	V. slight.	1.20	5.35	2.10	.0012	.0250	.0218	.0032	.50	.0020	.0002	1.3
9295	Aug. 24	Aug. 24	V. slight.	Slight.	0.90	5.20	2.00	.0024	.0210	.0180	.0030	.63	.0000	.0001	0.5
9471	Sept. 29	Sept. 30	Slight.	V. slight.	0.65	4.90	1.80	.0000	.0180	.0160	.0020	.66	.0120	.0000	1.4
9574	Oct. 26	Oct. 27	Slight.	Cons., rusty.	0.40	4.75	1.30	.0000	.0142	.0126	.0016	.65	.0050	.0000	1.3
9740	Nov. 29	Nov. 30	Slight.	Slight.	1.50	7.30	2.90	.0010	.0326	.0264	.0062	.67	.0150	.0002	1.7
9812	Dec. 20	Dec. 21	Slight.	Slight.	1.10	6.35	2.75	.0010	.0240	.0204	.0036	.65	.0250	.0001	1.7
Av.	....	....	....	....	1.08	5.27	2.20	.0012	.0225	.0198	.0027	.54	.0093	.0001	1.1

Odor, distinctly vegetable and grassy and occasionally mouldy. —— The samples were collected from the river opposite the filter-basin of the Taunton Water Works.

Microscopical Examination.

The number of organisms found in these samples varied from 16 to 181 per cubic centimeter, and averaged 71.

TISBURY.

WATER SUPPLY OF TISBURY. — VINEYARD HAVEN WATER COMPANY.

Chemical Examination of Water from the Filter-Gallery at Tashmoo Spring.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9201	Aug. 5	Aug. 6	None.	None.	0.0	4.00	.0000	.0000	.95	.0000	.0000	0.8	.0058

Odor, none. —— The sample was collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No organisms.

TYNGSBOROUGH.

Chemical Examination of Water from Bridge Meadow Brook, in Tyngsborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8968	June 6	June 7	Slight.	Slight.	1.20	4.70	1.90	.0006	.0226	.0196	.0030	.15	.0030	.0002	0.9

Odor, vegetable and mouldy, becoming disagreeable on heating. —— The sample was collected from the brook at a point where it is crossed by a road about one and one half miles above Tyngsborough Village. The sample was collected during an investigation for a new water supply for the city of Lowell.

Microscopical Examination.

Diatomaceæ, *Synedra*, 56; *Tabellaria*, 2. Fungi, *Crenothrix*, 24. Miscellaneous, *Zoöglœa*, 3. Total, 85.

WATER SUPPLY OF UXBRIDGE.

In October, 1892, the town of Uxbridge asked the advice of the State Board of Health with reference to an additional water supply to be taken either from Mendon Pond in the town of Mendon or from Crony Brook in Uxbridge. The advice of the Board in regard to these sources may be found on page 46 of this report. The analysis of a sample of water from a spring feeding Crony Brook is

UXBRIDGE.

given in one of the following tables, and an analysis of a sample of water from Mendon Pond may be found on page 185 of this report.

Chemical Examination of Water from a Faucet in Uxbridge supplied from the Reservoirs.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.												
9247	Aug. 15	Aug. 16	None.	None.	0.0	2.85	.0000	.0000	.14	.0100	.0001	1.3	.0350

Odor, none. —— The sample was collected from a faucet in the village.

Microscopical Examination.

No organisms.

Chemical Examination of Water from a Spring at Crony Brook, Uxbridge.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Examination.	Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1892.												
9593	Oct. 29	Oct. 31	None.	None.	0.0	2.75	.0000	.0000	.15	.0070	.0000	0.5	.0000

Odor, none. —— The sample was collected from a spring at Crony Brook, a short distance from the springs now used as a source of supply for Uxbridge.

Microscopical Examination.

Cyanophyceæ, *Rivularia*, 22.

Water Supply of Waltham.

The water commissioners of Waltham applied to the State Board of Health in August, with reference to the preservation of the purity of the water supply of the city, and the reply of the Board to this application may be found on page 48 of this report. As stated in previous reports, the source of supply is a well forty feet in diameter, sunk in 1891, in the bottom of an open filter-basin which had been used as a source of supply since 1873. The filter-basin has a depth of about eight and four-tenths feet below the water level in Charles

River, and the well an additional depth of eighteen feet. The contents of the well and filter-basin below the usual water level are about half as large as the amount of water pumped daily for the supply of the city, and the water is therefore changed very frequently. Notwithstanding this fact, a vegetable growth, mainly the filamentous blue-green Alga, *Oscillaria*, grows in great abundance upon the bottom of the filter-basin and upon the bottom of the well, and affects the quality of the water so much that it generally has an unpleasant or disagreeable odor when examined in the laboratory. That this is not the condition of the water as it comes from the ground has been proved by excavating a small hole at the side of the filter-basin just above the water level, thus creating a spring, and taking the water from it just as it comes from the ground. An analysis of a sample of water collected from the spring is given on the following page.

Chemical Examination of Water from the Well and Filter-Basin of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8429	Jan. 18	Jan. 19	None.	None.	0.00	6.55	.0004	.0010	.44	.0300	.0000	2.9	-
8496	Feb. 9	Feb. 10	None.	None.	0.00	6.55	.0012	.0034	.45	.0250	.0001	3.2	-
8528	Feb. 17	Feb. 18	None.	None.	0.00	6.55	.0012	.0028	.44	.0180	.0000	2.3	-
8592	Mar. 8	Mar. 9	V. slight.	None.	0.00	6.90	.0164	.0112	.46	.0140	.0000	3.2	-
8751	Apr. 18	Apr. 19	None.	None.	0.00	6.10	.0000	.0014	.42	.0200	.0002	3.1	-
8928	May 24	May 25	V. slight.	None.	0.00	6.60	.0022	.0014	.45	.0220	.0001	3.2	-
8985	June 8	June 9	None.	None.	0.00	7.80	.0034	.0024	.50	.0030	.0000	3.2	-
9091	July 12	July 13	None.	None.	0.00	7.00	.0032	.0002	.45	.0090	.0000	3.9	.0046
9219	Aug. 9	Aug. 10	None.	Slight.	0.00	7.40	.0022	.0014	.45	.0100	.0000	3.6	.0054
9397	Sept. 19	Sept. 20	None.	None.	0.00	6.80	.0030	.0012	.44	.0100	.0001	3.5	.0050
9530	Oct. 13	Oct. 14	None.	Slight.	0.01	6.90	.0024	.0058	.44	.0200	.0000	3.6	.0020
9653	Nov. 9	Nov. 10	None.	V. slight.	0.01	6.75	.0040	.0010	.43	.0150	.0001	4.2	.0010
9764	Dec. 6	Dec. 7	None.	V. slight.	0.02	6.60	.0028	.0024	.44	.0200	.0000	3.6	.0025
Av.	....	....	....	....	0.00	6.81	.0033	.0027	.45	.0162	.0000	3.4	.0034

Odor, generally unpleasant or disagreeable, sometimes very disagreeable, frequently none; on heating the odor is generally not so strong, and occasionally disappears; sample No. 9219 contained .0180 part of manganese. —— The samples were collected from a faucet at the pumping station while pumping. The suction pipe of the pump from which the samples were taken extends nearly to the bottom of the well.

WALTHAM.

Microscopical Examination of Water from the Well and Filter-Basin of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1892.												
	Jan.	Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	11	19	10	20	26	10	13	12	21	15	11	7
Number of sample,	8429	8496	8528	8592	8751	8928	8985	9091	9219	9397	9530	9653	9764
PLANTS.													
Diatomaceæ,	**21**	**13**	**3**	**36**	**44**	**52**	**16**	**0**	**0**	**0**	**10**	**9**	**4**
Asterionella,	12	8	0	8	30	46	8	0	0	0	2	3	0
Melosira,	5	0	0	1	0	1	0	0	0	0	8	6	1
Synedra,	4	5	3	27	14	5	8	0	0	0	0	0	3
ANIMALS.													
Infusoria. Dinobryon,	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**2**	**3**	**0**	**3**	**2**	**1**	**0**	**4**	**0**	**0**	**0**	**36**	**4**
TOTAL,	23	16	3	39	46	55	16	4	0	0	10	45	8

In addition to the suspended organisms which appear in the samples examined in the laboratory, as above recorded, there is a large amount of the filamentous blue-green alga, *Oscillaria*, growing in this water, attached to the bottom and sides of the filter-basin and well.

Chemical Examination of a Spring beside the Filter-Basin of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9558	Oct. 22	Oct. 24	None.	V. slight.	0.0	5.60	.0000	.0014	.46	.0100	.0000	2.5	.0000

Odor, none. —— The sample was collected from a spring-hole dug on the shore of the filter-basin, with a view to getting the water just as it comes from the ground.

Microscopical Examination.

Diatomaceæ, *Navicula*, 1.

WALTHAM.

Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.														
8428	Jan. 18	Jan. 19	Distinct.	Cons.	0.00	5.75	.0000	.0070	.0026	.0044	.43	.0100	.0000	3.0	–
8495	Feb. 9	Feb. 10	Slight.	Cons., green.	0.00	6.35	.0000	.0064	.0020	.0044	.43	.0450	.0001	2.9	–
8529	Feb. 17	Feb. 18	Slight.	Cons.	0.00	6.30	.0006	.0092	.0036	.0056	.47	.0220	.0000	2.7	–
8591	Mar. 8	Mar. 9	Slight.	Cons., green.	0.00	6.00	.0036	.0160	.0086	.0074	.43	.0120	.0001	2.9	–
8750	Apr. 18	Apr. 19	Slight.	Slight.	0.00	5.80	.0000	.0066	.0026	.0040	.44	.0100	.0001	3.0	–
8927	May 24	May 25	Slight.	Cons., green.	0.00	6.30	.0010	.0098	.0028	.0070	.43	.0120	.0000	2.6	–
8984	June 8	June 9	Distinct, green.	Slight, green.	0.02	6.30	.0000	.0142	–	–	.48	.0050	.0003	2.8	–
9092	July 12	July 13	Slight.	Heavy, white.	0.00	6.50	.0018	.0066	–	–	.45	.0050	.0000	3.2	–
9220	Aug. 9	Aug. 10	Distinct.	Cons.	0.00	6.75	.0000	.0056	–	–	.45	.0100	.0000	3.2	.0252
9398	Sept. 19	Sept. 20	Distinct.	Cons.	0.08	6.30	.0000	.0076	.0022	.0054	.42	.0100	.0003	2.9	.0000
9531	Oct. 13	Oct. 14	Slight.	Cons.	0.05	6.70	.0000	.0038	–	–	.44	.0200	.0000	3.4	.0050
9652	Nov. 9	Nov. 10	Distinct.	Cons.	0.01	6.20	.0000	.0094	.0026	.0068	.42	.0070	.0002	3.5	.0000
9765	Dec. 6	Dec. 7	Slight.	V. slight.	0.02	6.45	.0000	.0046	–	–	.46	.0080	.0000	3.2	.0050
Av.	....	....	....	....	0.01	6.28	.0006	.0082	–	–	.44	.0119	.0001	3.0	.0070

Odor, faintly vegetable and aromatic, or none; when heated the odor is stronger, generally vegetable, occasionally unpleasant or disagreeable and very seldom none. —— The samples were collected from the gate-house at the reservoir.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1892.												
	Jan.	Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	20	11	20	10	20	26	10	13	12	21	15	10	7
Number of sample, . .	8428	8495	8529	8591	8750	8927	8984	9092	9220	9398	9531	9652	9765
PLANTS.													
Diatomaceæ, . . .	**7,736**	**9,312**	**8,293**	**13,920**	**4,588**	**12,116**	**6,592**	**2.830**	**1,234**	**2.717**	**1,206**	**2,942**	**637**
Asterionella, . . .	7,736	9,000	8,080	11,920	2,704	11,520	5,920	2,504	988	1,472	1,112	486	214
Cyclotella, . . .	0	0	0	0	180	4	0	0	0	4	0	0	pr.
Fragilaria, . . .	0	0	0	0	0	0	0	0	0	0	12	16	0
Melosira, ...	0	0	5	0	0	0	0	0	5	5	0	0	9
Synedra, ...	0	312	208	2,000	1,704	592	672	2	9	20	26	0	94
Tabellaria, . . .	0	0	0	0	0	0	0	324	232	1,216	56	2,440	320

WALTHAM.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.												
	Jan.	Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.													
Cyanophyceæ. Chroöcoccus,	0	8	0	0	0	0	0	0	0	0	0	0	0
Algæ,	16	16	7	16	4	12	22	1,079	677	32	16	0	43
Chlorococcus,	16	2	0	16	2	12	18	12	8	0	10	0	0
Conferva,	0	0	7	0	0	0	0	1	0	0	0	0	pr.
Protococcus,	0	0	0	0	0	0	0	1,040	660	16	0	0	43
Raphidium,	0	0	0	0	0	0	0	25	0	0	6	0	0
Scenedesmus,	0	0	0	0	2	0	0	1	9	3	0	0	pr.
Tetraspora,	0	0	0	0	0	0	4	0	0	13	0	0	0
Zoöspores,	0	14	0	0	0	0	0	0	0	0	0	0	0
Fungi. Crenothrix,	8	1	0	0	0	0	0	0	0	0	0	0	0
ANIMALS.													
Infusoria,	224	0	0	0	204	16	266	30	191	1	0	pr.	11
Dinobryon,	4	0	0	0	144	16	258	0	2	0	0	0	7
Dinobryon cases,	0	0	0	0	60	0	6	30	188	0	0	0	0
Encysted Protozoan,	0	0	0	0	0	0	2	0	0	0	0	0	0
Trachelomonas,	220	0	0	0	0	0	0	0	1	1	0	pr.	pr.
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	0	4
Crustacea. Daphnia,	0	0	0	0	0	0	0	.06	0	0	0	0	0
Miscellaneous. Zoöglœa,	2	0	11	0	0	0	30	0	780	8	3	0	0
TOTAL,	7,986	9,337	8,311	13,936	4,796	12,144	6,910	3,939	2,882	2,758	1,225	2,942	691

Chemical Examination of Water from Faucets in Waltham, supplied from the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9251	Aug. 15	Aug. 16	Slight, milky.	V. slight.	0.70	7.25	.0042	.0056	.45	.0050	.0000	4.2	.4000
9252	Aug. 15	Aug. 16	Slight, rusty.	Heavy, rusty.	0.03	8.80	.0000	.0144	.44	.0180	.0001	3.8	.0400

Odor of the first sample, distinctly tarry, becoming somewhat stronger on heating; of the second sample, none, becoming faintly vegetable on heating. The first sample contained .0400 and the second .1600 part of manganese. —— The samples were collected from a faucet in a house on Morton Street, the first just before and the last just after flushing the main pipe. The main had not been flushed for two weeks previous to this date.

Microscopical Examination.

No. 9251. Diatomaceæ, *Synedra*, 1. Miscellaneous, *iron rust*, 376. Total, 377.

No. 9252. Diatomaceæ, *Asterionella*, 1,552; *Melosira*, 4; *Stauroneis*, 2; *Tabellaria*, 264. Algæ, *Cosmarium*, 6; *Protococcus*, 38. Infusoria, *Dinobryon*, 20; *Dinobryon cases*, 14; *Peridinium*, 2; *Trachelomonas*, 4. Vermes, *Rotifer*, 4. Total, 1,910.

WALTHAM.

Chemical Examination of Water from a Well at the School for the Feeble-minded, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8494	Feb. 9	Feb. 10	None.	None.	0.0	7.30	.0000	.0038	.75	.2100	.0000	3.1	-

Odor, none. —— The sample was collected from a well constructed in 1890, just west of a small brook, north-east of the asylum.

Microscopical Examination.

Diatomaceæ, *Synedra*, 12. Fungi, *Crenothrix*, 16. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 1. Total, 30.

Water Supply of Ware.

Chemical Examination of Water from the Well of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8506	Feb. 11	Feb. 12	None.	None.	0.0	11.05	.0000	.0008	1.12	.6000	.0000	3.6	-
9080	July 9	July 12	None.	None.	0.0	10.75	.0000	.0004	1.20	.5500	.0000	3.4	-
9824	Dec. 21	Dec. 22	None.	None.	0.0	9.80	.0000	.0012	1.12	.5500	.0000	4.3	.0000
Av.	....	....	....	....	0.0	10.53	.0000	.0008	1.15	.5666	.0000	3.8	-

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

WARREN.

Warren.

Chemical Examination of Water from Tubular Test Wells in Warren.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation.	Ammonia: Free.	Ammonia: Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9174	July 25	Aug. 2	Decided, clayey.	Cons., rusty.	0.0	5.40	.0024	.0000	.12	.0000	.0000	2.2	.1440
9202	Aug. 5	Aug. 6	Slight, clayey.	Much, rusty gravel.	0.0	3.45	.0000	.0000	.27	.0950	.0002	1.3	.0130
9203	Aug. 5	Aug. 6	Slight.	Much, rusty gravel.	0.0	4.60	.0000	.0000	.39	.0500	.0001	1.9	.0108

Odor of the first two samples, none; of the last, earthy.—— The first and third samples were collected from two and one-half inch tubular wells, thirty-one and sixteen feet, respectively, in depth, on the south side of the Quaboag River, about one-half to three-quarters of a mile east of Warren. The second was collected from a two and one-half inch tubular well, twenty-one feet deep, three hundred feet east of Comins Pond, Warren. The last two samples contained gravel and other earthy matter pumped from the wells, and therefore had to be filtered through filter paper before being analyzed.

Microscopical Examination.

No. 9174. Iron rust very abundant.
Nos. 9202 and 9203, not examined.

Water Supply of Watertown and Belmont, — Watertown Water Supply Company.

Chemical Examination of Water from the Filter-Gallery of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance: Turbidity.	Appearance: Sediment.	Appearance: Color.	Residue on Evaporation.	Ammonia: Free.	Ammonia: Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9464	Sept. 28	Sept. 29	Slight.	V. slight.	0.12	7.85	.0030	.0040	.65	.0300	.0001	3.8	.0450
9555	Oct. 20	Oct. 22	Slight.	Slight.	0.06	7.85	.0038	.0042	.65	.0400	.0000	3.5	.0280
9678	Nov. 15	Nov. 17	Slight.	Slight, fibrous.	*0.05	7.80	.0042	.0058	.66	.0300	.0001	4.8	.0230
9792	Dec. 14	Dec. 15	Slight.	V. slight.	0.05	8.10	.0056	.0044	.67	.0480	.0001	4.1	.0625
Av.	....	....	....	....	0.07	7.90	.0041	.0046	.66	.0370	.0001	4.0	.0396

Odor of the first sample, faintly vegetable; of the others, none.—— The first sample was collected from the gallery at the end nearest the pumping station; the remaining samples were collected from the gallery at the entrance to the conduit leading to the large well. During the time covered by these analyses, all water flowed from the filter-gallery into the large well near the river bank, and was pumped from there for the supply of the towns.

* The color of this sample increased to 0.08 after standing three days.

WATERTOWN.

Microscopical Examination of Water from the Filter-Gallery of the Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1892.			
	Sept.	Oct.	Nov.	Dec.
Day of examination,	29	24	17	15
Number of sample,	9464	9555	9678	9792
PLANTS.				
Diatomaceæ. Tabellaria,	0	0	1	0
Fungi. Crenothrix,	772	60	24	10
Miscellaneous. Zoöglœa,	pr.	152	63	1
TOTAL,	772	212	88	11

Chemical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9463	Sept. 28	Sept. 29	Slight.	V. slight.	0.15	7.70	.0090	.0064	.71	.0250	.0001	3.9	.0450
9556	Oct. 20	Oct. 22	Slight.	Slight.	0.08	7.90	.0054	.0048	.69	.0350	.0000	3.8	.0500
9677	Nov. 15	Nov. 17	Slight.	V. slight.	0.08	7.65	.0046	.0058	.73	.0280	.0001	4.0	.0450
9791	Dec. 14	Dec. 15	Slight.	V. slight	0.08	7.90	.0048	.0040	.67	.0500	.0001	4.0	.0230
Av.	....	....	....	....	0.10	7.79	.0059	.0052	.70	.0345	.0001	3.9	.0407

Odor of the first sample, faintly vegetable; of all others, none.—— These samples represent a mixture of water from the filter-gallery and the new large well.

WATERTOWN.

Microscopical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1892.			
	September.	October.	November.	December.
Day of examination,	29	24	17	15
Number of sample,	9463	9556	9677	9791
PLANTS.				
Diatomaceæ,	1	0	1	2
Synedra,	0	0	1	0
Tabellaria,	1	0	0	2
Cyanophyceæ. Oscillaria,	0	0	1	0
Fungi. Crenothrix,	9	15	18	6
Miscellaneous. Zoöglœa,	pr.	88	54	0
TOTAL,	11	103	75	8

Chemical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9173	Aug. 1	Aug. 1	Slight, milky.	None.	0.0	10.20	.0022	.0056	.65	.0300	.0015	3.9	.0077

Odor, none.——The sample was collected from a faucet in a house in the easterly part of Watertown.

Microscopical Examination.

No organisms.

WATERTOWN.

Chemical Examination of Water from a Large Test Well of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9560	Oct. 23	Oct. 24	Distinct, clayey.	Cons., earthy.	0.60	11.95	.0236	.0074	.74	.0070	.0000	3.8	.2400

Odor, when heated, faintly vegetable and unpleasant.——The sample was collected from the well, which is located about one hundred and twenty-five feet from Charles River, on the same side as the present works, and a short distance below them. The well was not covered, and had been pumped from every three weeks for several months.

Microscopical Examination.

Fungi, *Crenothrix*, 2. Miscellaneous, *Zoöglœa*, 3. Total, 5.

Chemical Examination of Water from Charles River at Watertown.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9559	Oct. 23	Oct. 24	Distinct.	Cons.	0.50	7.10	1.80	.0008	.0216	.0174	.0042	.78	.0550	.0008	2.8

Odor, distinctly musty.——The sample was collected from the river opposite the works of the Watertown Water Supply Company.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 1; *Diatoma*, 1; *Navicula*, 2. Fungi, *Crenothrix*, 348. Infusoria, *Monas*, 1. Miscellaneous, *Zoöglœa*, 280. Total, 633.

WAYLAND.

Water Supply of Wayland.

Chemical Examination of Water from the Filter-Gallery of the Wayland Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9583	Oct. 27	Oct. 28	Decided.	Cons., yellow.	0.20	*4.60 4.00	*1.30 0.80	.0156	.0122	.0084	.0038	.27	.0100	.0000	1.8

Iron, 0.1400 parts in unfiltered water, and 0.0400 parts after filtration through filter paper.

Odor, very faintly vegetable, becoming stronger and unpleasant on heating.——The sample was collected from a faucet in the gate-house, supplied from the filter-gallery.

* These determinations were made upon the water before filtration through filter-paper.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 1; *Diatoma*, 1; *Melosira*, 106. Cyanophyceæ, *Microcystis*, 2. Algæ, *Staurastrum*, 1. Fungi, *Crenothrix*, 22,842. Infusoria, *Ceratium*, 20; *Trachelomonas*, 1. Total, 22,974.

Water Supply of Wellesley.

Chemical Examination of Water from the Filter-Gallery and Well of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9526	Oct. 12	Oct. 13	None.	Slight.	0.0	7.90	.0000	.0000	.53	.0550	.0000	3.8	.0000
9525	Oct. 12	Oct. 13	None.	Slight.	0.0	6.55	.0000	.0034	.65	.0950	.0001	2.4	.0000

Odor, none.——The first sample was collected from the filter-gallery; the second sample, from the well at Williams Spring.

Microscopical Examination.

No organisms.

WELLESLEY.

Chemical Examination of Water from Faucets in Wellesley, supplied from the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9527	Oct. 12	Oct. 13	None.	V. slight.	0.0	8.40	.0000	.0028	.57	.1400	.0000	3.9	.0075
9528	Oct. 12	Oct. 13	Slight.	V. slight.	0.0	8.45	.0000	.0028	.57	.1100	.0000	4.3	.0090

Odor, none. —— The first sample was collected from a faucet in a dwelling-house, about four and a half miles from the pumping station; the second sample, from a faucet in a dwelling-house about five miles from the pumping station and near the end of the pipe system.

Microscopical Examination.

No. 9527, Diatomaceæ, *Tabellaria*, 1. Algæ, *Chlorococcus*, 2. Total, 3.
No. 9528, Algæ, *Chlorococcus*, 19; *Protococcus*, 1. Total, 20.

Chemical Examination of Water from Tubular Test Wells in Wellesley.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8497	Feb. 9	Feb. 10	None.	None.	0.0	4.10	.0000	.0004	.38	.0220	.0000	1.4	-
8509	Feb. 12	Feb. 13	None.	None.	0.0	4.95	.0032	.0010	.42	.0520	.0000	1.8	-

The second sample became milky in appearance on standing, and a color of 0.20 was developed, together with a slight sediment, due to the precipitation of iron.

Odor, none. —— The samples were collected from tubular test wells two and one-half inches in diameter, on the shore of Morse's Pond. The first sample was from a well eighteen feet deep and forty-five feet from the shore of the pond; the second sample was from a well thirty feet deep and fifty feet from the shore of the pond.

Microscopical Examination.

No. 8497. Diatomaceæ, *Asterionella*, 7; *Synedra*, 4. Infusoria, *Chloromonas*, 4. Miscellaneous, *Zoöglœa*, 8. Total, 23.

No. 8509. Miscellaneous, *Zoöglœa*, 364.

WESTBOROUGH.

Water Supply of Westborough.

Chemical Examination of Water from Springs between the Upper and Lower Reservoirs, Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
9590	Oct. 28	Oct. 29	None.	None.	0.00	2.70	.0000	.0016	.20	.0000	.0000	0.8	.0020
9561	Oct. 28	Oct. 29	Distinct.	Heavy, yellow.	0.20	2.65	.0166	.0026	.17	.0090	.0001	0.5	.2250

Odor of first sample, none; of last sample, distinctly vegetable, becoming mouldy and unpleasant on standing. —— These springs derive their supply from the upper reservoir. In the first case the water is very thoroughly purified by its passage through the ground; while in the second case it is not well purified, owing, probably, both to the shorter distance that this water has filtered through the ground and to the greater amount of vegetable matter in the ground through which the water filters.

Microscopical Examination.

No. 9590. No organisms.
No. 9591. Fungi, *Crenothrix*, 142. Miscellaneous, *Zoöglœa*, 46. Total, 188.

Westford.

Chemical Examination of Water from Stony and Keyes Brooks, at Westford.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9046	June 29	June 30	Slight.	Slight.	0.65	4.40	2.00	.0004	.0220	.0130	.0090	.19	.0000	.0000	1.7
9047	June 29	June 30	V. slight.	Slight.	0.90	3.60	2.00	.0000	.0252	.0234	.0018	.14	.0000	.0000	0.8

Odor of each sample, faintly vegetable, becoming stronger on heating. —— The first sample was collected from Stony Brook above the mill at Forge Village; the last, from Keyes Brook, a tributary of Stony Brook, at the first road crossing below Keyes Pond. The samples were collected during an investigation for a new water supply for the city of Lowell.

Microscopical Examination.

No. 9046. Diatomaceæ, *Asterionella*, 10; *Cyclotella*, 5; *Diatoma*, 3; *Grammatophora*, 1; *Melosira*, 4; *Navicula*, 2; *Synedra*, 9; *Tabellaria*, 2. Cyanophyceæ, *Chroöcoccus*, 8; *Clathrocystis*, 1; *Cœlosphærium*, 1; *Microcystis*, 3. Algæ, *Botrycoccus*, 1; *Chlorococcus*, 2; *Raphidium*, 7. Infusoria, *Dinobryon cases*, 39; *Peridinium*, 14; *Anurea*, 1. Miscellaneous, *Zoöglœa*, 6. Total, 119.

No. 9047. Diatomaceæ, *Asterionella*, 3; *Cyclotella*, 274; *Melosira*, 1; *Tabellaria*, 15. Cyanophyceæ, *Anabæna*, 2; *Chroöcoccus*, 22; *Cœlosphærium*, 1; *Microcystis*, 3. Algæ, *Botrycoccus*, 1; *Chlorococcus*, 90; *Raphidium*, 1; *Staurastrum*, 2; *Tetraspora*, 1. Infusoria, *Dinobryon cases*, 1. Miscellaneous, *Zoöglœa*, 5. Total, 422.

Water Supply of West Springfield.

The works of the West Springfield Aqueduct Company were purchased by the town of West Springfield July 1, 1892.

Water Supply of Weymouth.

Chemical Examination of Water from Great Pond, and from Faucets in Weymouth, supplied from the Weymouth Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8418	Jan. 12	Jan. 13	V.slight	None.	1.40	4.25	2.20	.0000	.0208	.0176	.0032	.47	.0030	.0000	0.3
8692	Apr. 1	Apr. 1	Slight.	Slight.	1.30	4.40	2.25	.0000	.0178	.0170	.0008	.54	.0100	.0000	0.3
8895	May 14	May 14	V.slight.	Slight.	0.90	3.75	1.85	.0000	.0164	.0148	.0016	.46	.0070	.0000	0.3
9107	July 13	July 15	Slight.	Cons., rusty.	0.85	3.60	1.60	.0000	.0164	.0148	.0016	.53	.0030	.0000	0.5
9351	Sept. 7	Sept. 7	V.slight.	V.slight.	0.60	3.80	1.55	.0002	.0182	.0162	.0020	.52	.0180	.0000	0.5
9636	Nov. 7	Nov. 7	V.slight.	None.	0.60	3.10	1.70	.0000	.0142	.0130	.0012	.54	.0050	.0001	0.6
Av.	....	....	....	....	0.94	3.82	1.86	.0000	.0173	.0156	.0017	.51	.0077	.0000	0.4

Odor of the first four samples, vegetable; of the last two, none; on heating, the odor in each of the first four samples became stronger, and a faintly mouldy odor was developed in the fifth.—— Samples numbered 8692 and 8895 were collected from a faucet at the pumping station while pumping; the remaining samples were collected from faucets in the town.

Microscopical Examination of Water from Great Pond, and from Faucets in Weymouth, supplied from the Weymouth Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	April.	May.	July.	Sept.	Nov.
Day of examination,	14	5	17	15	9	9
Number of sample,	8418	8692	8895	9107	9351	9636
PLANTS.						
Diatomaceæ,	**5**	**65**	**16**	**3**	**0**	**0**
Asterionella,	2	6	4	0	0	0
Ceratoneis,	0	0	0	3	0	0
Cyclotella,	1	3	0	0	0	0
Diatoma,	0	26	1	0	0	0
Melosira,	0	0	3	0	0	0
Synedra,	2	30	8	0	0	0
Cyanophyceæ,	**0**	**0**	**0**	**97**	**0**	**0**
Chlorococcus,	0	0	0	8	0	0
Merismopedia,	0	0	0	89	0	0

WEYMOUTH.

Microscopical Examination of Water from Great Pond, and from Faucets in Weymouth, supplied from the Weymouth Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.					
	Jan.	April.	May.	July.	Sept.	Nov.
PLANTS — Con.						
Algæ,	4	8	pr.	8	0	0
Chlorococcus,	0	8	pr.	8	0	0
Zoöspores,	4	0	0	0	0	0
Fungi. Crenothrix,	0	0	0	68	0	0
ANIMALS.						
Rhizopoda. Difflugia,	0	0	0	1	0	0
Infusoria,	2	36	1	1	0	0
Cryptomonas,	0	pr.	0	0	0	0
Dinobryon,	0	14	0	0	0	0
Dinobryon cases,	0	21	1	0	0	0
Monas,	1	pr.	0	0	0	0
Peridinium,	pr.	0	pr.	0	0	0
Rhipidodendron,	0	0	0	1	0	0
Synura,	0	1	0	0	0	0
Trachelomonas,	1	0	0	0	0	0
Vermes. Sacculus,	0	0	0	1	0	0
Miscellaneous. Zoöglœa,	5	7	33	148	0	16
TOTAL,	16	116	50	327	0	16

WATER SUPPLY OF WILLIAMSTOWN. — WILLIAMSTOWN WATER COMPANY.

In 1892 this company obtained an additional supply by taking water from Paul Brook, which is situated in North Adams just east of the Williamstown line, and flows through a ravine in the northerly slope of Saddle Mountain. A dam fifty feet long and ten feet high was constructed across the ravine, forming a small reservoir. A pipe six inches in diameter and three-fourths of a mile long conveys water from this reservoir into the old reservoir on the north side of the mountain.

The advice of the State Board of Health to the Williamstown Water Company with reference to this source may be found on page 50 of this report.

WILLIAMSTOWN.

Chemical Examination of Water from the Old Reservoir on the North Side of Saddle Mountain.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8695	Apr. 1	Apr. 4	Slight, clayey.	V. slight.	0.0	9.20	1.05	.0000	.0058	.0034	.0024	.07	.0200	.0000	6.7

Odor, none. —— The sample was collected from the first tap below the reservoir, where the water is allowed to run continuously.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 3.

Chemical Examination of Water from Paul Brook, North Adams.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8694	Apr. 1	Apr. 4	V. slight.	Cons., earthy.	0.0	3.25	1.00	.0000	.0120	.0112	.0008	.07	.0120	.0000	2.2

Odor, none. —— The sample was collected from the brook a short distance east of the Williamstown line, during an investigation for an additional source of water supply for the Williamstown Water Company.

Microscopical Examination.

Diatomaceæ, *Epithemia*, 1; *Meridion*, 8; *Synedra*, 1. Miscellaneous, *Zoöglœa*, 10. Total, 20.

Winchendon.

The advice of the State Board of Health with reference to the introduction of a partial water supply for the village of Winchendon from a well on Benjamin Hill may be found on page 51 of this report.

WINCHENDON.

Chemical Examination of Water from a Deep Tubular Well on Benjamin Hill.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites	Hardness.
	1892.											
8693	Apr. 2	Apr. 2	None.	None.	0.0	2.60	.0000	.0020	.12	.0150	.0000	0.3

Odor, none. —— The well is one hundred and twenty-six feet in depth.

Microscopical Examination.

No organisms.

Water Supply of Winchester.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8393	Jan. 5	Jan. 6	Slight.	Slight.	0.05	5.10	1.30	.0060	.0234	.0216	.0018	.57	.0180	.0001	2.2
8480	Feb. 2	Feb. 3	V. slight.	V. slight.	0.08	6.75	2.80	.0072	.0334	.0272	.0062	.67	.0280	.0001	2.7
8577	Mar. 4	Mar. 4	V. slight.	V. slight.	0.05	4.35	1.10	.0036	.0186	.0168	.0018	.57	.0300	.0001	2.9
8710	Apr. 5	Apr. 6	V. slight.	Slight.	0.05	5.25	1.15	.0106	.0220	.0158	.0062	.58	.0400	.0005	2.3
8859	May 5	May 6	Distinct.	V. slight.	0.03	5.10	1.60	.0020	.0214	.0162	.0052	.56	.0500	.0002	2.2
8963	June 2	June 2	V. slight.	Slight.	0.03	5.35	1.90	.0044	.0230	.0192	.0038	.64	.0280	.0004	2.3
9000	June 15	June 15	Slight.	Slight, green.	0.04	6.00	2.00	.0018	.0190	.0172	.0018	.64	.0180	.0005	1.9
9068	July 5	July 5	Slight.	Slight.	0.08	4.90	1.35	.0050	.0232	.0170	.0062	.60	.0090	.0003	1.9
9190	Aug. 2	Aug 2	Slight.	Slight.	0.03	5.20	1.75	.0000	.0180	.0158	.0022	.60	.0000	.0001	3.0
9329	Sept. 1	Sept. 1	V. slight.	V. slight, green.	0.15	5.00	1.75	.0002	.0196	.0148	.0048	.62	.0000	.0000	2.5
9491	Oct. 4	Oct. 5	Slight.	Slight, yellow.	0.05	5.20	1.30	.0038	.0194	.0140	.0054	.56	.0070	.0000	2.5
9610	Nov. 2	Nov. 2	V. slight.	V. slight.	0.03	5.10	1.55	.0152	.0222	.0188	.0034	.61	.0070	.0000	2.3
9757	Dec. 5	Dec. 5	Slight.	Slight.	0.05	5.10	1.45	.0128	.0180	.0162	.0018	.66	.0180	.0001	2.8
Av.	....	....	....	....	0.06	5.23	1.59	.0058	.0217	.0177	.0040	.60	.0192	.0002	2.5

Odor, generally faintly vegetable, frequently none, rarely disagreeable. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

WINCHESTER.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1892.												
	Jan.	Feb.	Mar.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	3	9	6	7	3	16	5	3	2	5	3	6
Number of sample,	8393	8480	8577	8710	8859	8963	9000	9068	9190	9329	9491	9610	9757
PLANTS.													
Diatomaceæ,	**88**	**61**	**35**	**343**	**591**	**170**	**31**	**1**	**2**	**2**	**123**	**65**	**128**
Asterionella,	52	22	0	6	140	13	8	0	0	0	0	0	24
Cyclotella,	10	4	0	80	110	0	1	0	1	0	60	56	42
Diatoma,	1	0	0	pr.	13	0	0	0	0	2	1	0	2
Grammatophora,	0	0	0	0	0	0	0	0	0	0	0	9	0
Melosira,	0	0	1	0	4	0	1	0	0	0	6	0	0
Meridion,	0	0	0	1	4	1	0	0	0	0	0	0	0
Navicula,	0	0	0	pr.	0	pr.	0	0	1	0	4	0	0
Stephanodiscus,	0	0	0	0	0	120	0	0	0	0	0	0	0
Synedra,	25	35	34	256	320	36	21	1	0	0	52	0	60
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**5**	**12**	**208**	**23**	**85**	**12**	**47**	**0**
Anabæna,	0	0	0	0	0	5	1	0	3	1	1	42	0
Chroöcoccus,	0	0	0	0	0	0	7	204	0	0	0	1	0
Clathrocystis,	0	0	0	0	0	0	0	2	2	1	3	4	0
Cœlosphærium,	0	0	0	0	0	0	4	2	18	3	4	0	0
Microcystis,	0	0	0	0	0	0	0	pr.	0	80	4	0	0
Algæ,	**0**	**2**	**2**	**2**	**13**	**28**	**232**	**18**	**2**	**12**	**44**	**60**	**54**
Botrycoccus,	0	0	0	0	0	0	2	pr.	0	0	1	4	0
Chlorococcus,	0	2	0	pr.	4	9	196	10	pr.	0	6	48	0
Closterium,	0	0	0	0	pr.	0	0	0	0	0	0	0	42
Cosmarium,	0	0	0	0	4	0	0	0	1	0	0	0	pr.
Dictyosphærium,	0	0	0	0	0	10	0	0	0	0	0	0	0
Hyalotheca,	0	0	0	0	0	0	0	0	0	0	6	0	4
Nephrocytium,	0	0	0	0	0	0	0	2	0	4	15	0	7
Protococcus,	0	0	0	2	0	7	30	2	pr.	8	0	0	0
Raphidium,	0	0	0	0	0	0	3	4	1	0	9	8	0
Scenedesmus,	0	0	2	0	5	pr.	1	pr.	pr.	0	1	0	1
Sorastrum,	0	0	0	0	0	2	0	pr.	0	0	6	0	0
Fungi. Crenothrix,	**0**	**0**	**2**	**12**	**0**	**0**	**0**	**2**	**0**	**0**	**2**	**0**	**0**
ANIMALS.													
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**	**1**	**1**	**14**	**2**
Infusoria,	**6**	**1**	**pr.**	**109**	**74**	**0**	**76**	**2**	**5**	**41**	**1,774**	**17**	**3**
Dinobryon,	0	0	0	23	0	0	0	0	0	0	49	0	0
Dinobryon cases,	0	pr.	0	84	68	0	74	0	0	37	1,716	2	0
Peridinium,	4	1	pr.	1	2	0	1	2	1	2	2	0	1
Trachelomonas,	2	0	0	1	4	0	1	0	1	2	7	13	2
Vorticella,	0	0	0	0	0	0	0	0	3	0	0	2	0
Vermes. Monocerca,	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**0**	**0**	**2**	**12**	**152**	**0**	**3**	**94**	**114**	**13**	**224**	**16**	**38**
TOTAL,	94	64	41	478	830	203	355	326	146	154	2,180	219	225

WINCHESTER.

Chemical Examination of Water from the South Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8394	Jan. 5	Jan. 6	V. slight.	Slight.	0.60	5.50	2.25	.0000	.0368	.0304	.0064	.38	.0350	.0002	2.0
8481	Feb. 2	Feb. 3	Slight.	Slight.	0.60	5.80	2.30	.0032	.0580	.0402	.0178	.33	.0250	.0002	2.1
8578	Mar. 4	Mar. 4	Slight.	Slight.	0.50	4.95	1.85	.0136	.0324	.0294	.0030	.42	.0100	.0005	2.2
8711	Apr. 5	Apr. 6	Slight.	Slight.	0.60	4.00	1.55	.0098	.0440	.0332	.0108	.34	.0180	.0002	2.1
8858	May 5	May 6	Distinct.	Cons.	0.50	4.95	1.85	.0008	.0386	.0302	.0084	.36	.0030	.0000	2.0
9001	June 15	June 15	Distinct, green.	Slight.	0.35	5.80	2.60	.0002	.0396	.0332	.0064	.38	.0070	.0002	2.1
9069	July 5	July 5	Distinct.	Slight.	0.28	4.90	2.05	.0014	.0386	.0310	.0076	.36	.0050	.0001	2.1
9189	Aug. 2	Aug. 2	Slight.	Cons., green.	0.30	4.80	1.70	.0000	.0332	.0260	.0072	.41	.0000	.0000	2.5
9328	Sept. 1	Sept. 1	Decided, green.	Slight.	0.35	5.15	2.15	.0000	.0340	.0266	.0074	.38	.0000	.0001	2.3
9492	Oct. 4	Oct. 5	Distinct.	Cons., yellow.	0.50	5.40	2.00	.0022	.0358	.0304	.0054	.35	.0100	.0000	2.5
9611	Nov. 2	Nov. 2	V. slight.	Slight.	0.80	5.55	2.20	.0240	.0378	.0348	.0030	.42	.0120	.0002	2.2
9758	Dec. 5	Dec. 5	Slight.	Slight.	0.70	5.30	1.95	.0106	.0418	.0362	.0056	.40	.0170	.0003	2.5
Av.	....	....	....	....	0.51	5.17	2.04	.0055	.0392	.0318	.0074	.38	.0118	.0002	2.2

Odor, generally vegetable and frequently mouldy or disagreeable. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	3	9	6	6	16	5	3	2	5	3	6
Number of sample,	8394	8481	8578	8711	8858	9001	9069	9189	9328	9492	9611	9758
PLANTS.												
Diatomaceæ,	27	pr.	24	2	674	30	2	2	21	17	2	10
Asterionella,	26	0	0	2	640	4	2	0	5	17	1	10
Synedra,	1	pr.	24	pr.	34	26	pr.	2	16	0	1	pr.
Cyanophyceæ. Anabæna,	0	0	0	0	0	292	38	34	1,264	280	0	0

WINCHESTER.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	0	0	0	0	4	1,117	1,777	132	18	77	4	1
Chlorococcus,	0	0	0	0	2	1,112	6	124	10	6	2	0
Cosmarium,	0	0	0	0	0	0	pr.	2	2	1	0	0
Pandorina,	0	0	0	0	0	0	0	2	5	1	0	0
Protococcus,	0	0	0	0	0	4	1,768	0	0	0	0	1
Raphidium,	0	0	0	0	0	1	3	0	0	2	0	0
Staurastrum,	0	0	0	0	0	pr.	pr.	3	0	3	0	0
Zoöspores,	0	0	0	0	2	0	0	1	1	64	2	0
Fungi. Crenothrix,	3	0	1	3	2	0	0	0	2	0	0	1
ANIMALS.												
Rhizopoda. Actinophrys,	1	0	0	2	4	0	2	2	5	0	0	0
Infusoria,	0	676	2	138	649	122	119	4	1	59	2	1
Chloromonas,	0	676	0	0	0	0	0	0	0	0	0	0
Cryptomonas,	0	0	0	54	1	0	0	0	0	0	0	pr.
Dinobryon,	0	0	0	82	524	0	78	0	0	11	0	0
Dinobryon cases,	0	0	0	0	120	108	36	1	0	3	0	0
Monas,	0	pr.	1	pr.	pr.	0	0	0	0	0	1	0
Peridinium,	0	0	pr.	0	0	pr.	4	1	0	1	0	0
Synura,	0	0	1	2	2	0	0	0	0	0	0	0
Trachelomonas,	0	0	pr.	pr.	2	1	1	2	1	44	1	1
Vorticella,	0	0	0	0	0	13	0	0	0	0	0	0
Vermes,	0	0	pr.	pr.	0	0	0	pr.	4	7	2	0
Anurea,	0	0	0	pr.	0	0	0	pr.	0	1	1	0
Conochilus,	0	0	0	0	0	0	0	0	0	5	0	0
Monocerca,	0	0	0	0	0	0	0	0	2	0	1	0
Polyarthra,	0	0	pr.	0	0	0	0	0	1	1	0	0
Rotatorian ova,	0	0	0	0	0	0	0	pr.	1	0	0	0
Crustacea,	0	.02	.11	0	0	.02	0	.04	.01	0	.06	0
Cyclops,	0	.02	.05	0	0	.02	0	.04	.01	0	.06	0
Daphnia,	0	0	.06	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	0	14	5	8	34	82	158	280	204	48	6
TOTAL,	31	676	41	150	1,341	1,595	2,020	332	1,595	644	58	19

WATER SUPPLY OF WINTHROP.

In July, 1892, a committee was appointed by the town to investigate the possibility of obtaining a water supply from some source within the limits of the town. The committee caused test wells to be driven in and near Ingalls Meadow, with a view to obtaining a supply of water from the ground. Five wells, each two and

WINTHROP.

one-half inches in diameter, were driven in the meadow, in a line running from its easterly edge toward its centre, the extreme wells in the line being one hundred feet apart. A sixth well was driven in the edge of the upland, about thirty feet from the first well in the meadow. The wells averaged thirty-four feet in depth, and those in the meadow were driven through fifteen to eighteen feet of meadow muck and a stratum of fine sand into gravel. After a small amount of water had been pumped from each well by means of a hand pump, the first two samples given in the table below were collected for analysis. The five wells located in the meadow were then connected with a steam pump and subjected to a pumping test lasting about ten days, near the end of which the third sample was collected. The advice of the State Board of Health to the committee on water supply of the town of Winthrop with regard to taking a water supply from the source tested may be found on page 51 of this volume. For information regarding the present water supply of the town, see *Revere* (pages 223 and 224).

Chemical Examination of Water from Tubular Test Wells in Winthrop.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.		
	1892.												
9292	Aug. 24	Aug. 24	Decided.	Heavy, red.	0.08	*19.10 13.60	.0012	.0116	3.80	.0030	.0001	3.1	1.7000
9293	Aug. 24	Aug. 24	Distinct.	Cons., sand.	0.02	20.00	.0000	.0000	3.80	.2000	.0006	7.4	.0600
9350	Sept. 7	Sept. 7	Distinct, milky.	Slight, rusty.	†0.10	13.70	.0176	.0000	3.09	.0750	.0006	4.6	.3000

Odor of the last sample, distinctly disagreeable; of the others, none. —— The first sample was collected from the middle well in the line of five in Ingalls Meadow; the second, from the well at the edge of the upland, and the last one from a steam pump drawing water from the five wells in the meadow.

Microscopical Examination.

No. 9292, not examined.
No. 9293, Fungi, *Crenothrix*, 15. Miscellaneous, *Iron*, 54. Total, 69.
No. 9350, Miscellaneous, *Iron*, 7520.

* This determination was made upon the water before filtration through filter-paper.
† The color increased to 1.00 after standing one day.

Water Supply of Woburn.

Chemical Examination of Water from the Filter-Gallery of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8400	Jan. 5	Jan. 6	None.	None.	0.0	11.25	.0014	.0010	1.80	.0800	.0000	4.9	–
8541	Feb. 19	Feb. 20	None.	None.	0.0	11.45	.0016	.0042	1.96	.0600	.0002	5.1	–
8648	Mar. 22	Mar. 23	None.	None.	0.0	10.40	.0010	.0024	1.93	.0800	.0000	5.0	–
8805	Apr. 26	Apr. 27	None.	None.	0.0	10.75	.0000	.0016	1.81	.0650	.0000	4.6	–
8930	May 24	May 26	None.	None.	0.0	11.10	.0020	.0054	2.00	.0650	.0000	5.0	–
9038	June 27	June 29	None.	None.	0.0	11.90	.0016	.0046	1.80	.0500	.0000	4.8	–
9162	July 26	July 28	None.	None.	0.0	11.55	.0012	.0000	1.99	.0550	.0000	5.1	–
9281	Aug. 19	Aug. 22	None.	None.	0.0	11.90	.0018	.0012	2.05	.0400	.0000	5.3	.0000
9452	Sept. 27	Sept. 28	None.	None.	0.0	11.20	.0006	.0032	1.98	.0350	.0000	5.5	.0000
9563	Oct. 25	Oct. 26	None.	None.	0.0	11.45	.0010	.0030	2.01	.0400	.0000	5.6	.0000
9705	Nov. 21	Nov. 22	None.	None.	0.0	11.15	.0014	.0016	1.96	.0400	.0000	5.6	.0000
9831	Dec. 21	Dec. 22	None.	None.	0.0	11.20	.0014	.0006	2.16	.0400	.0000	5.3	.0000
Av.	....	....	....	....	0.0	11.27	.0012	.0024	1.95	.0542	.0000	5.1	.0000

Odor, none. —— The samples were collected from the filter-gallery.

Microscopical Examination of Water from the Filter-Gallery of the Woburn Water Works.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	23	23	27	26	29	28	22	28	26	23	23
Number of sample,	8400	8541	8648	8805	8930	9038	9162	9281	9452	9563	9705	9831
PLANTS.												
Diatomaceæ,	6	pr.	pr.	72	9	0	0	0	0	0	0	0
Asterionella,	3	0	pr.	30	4	0	0	0	0	0	0	0
Diatoma,	0	0	0	24	1	0	0	0	0	0	0	0
Synedra,	3	pr.	pr.	18	4	0	0	0	0	0	0	0
Fungi. Crenothrix,	28	0	0	0	0	0	0	0	0	0	0	0
Total,	34	pr.	pr.	72	9	0	0	0	0	0	0	0

WOBURN.

Chemical Examination of Water from the Distributing Reservoir of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albu-minoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.	Iron.
	1892.												
8540	Feb. 19	Feb. 20	None.	None.	0.00	11.35	.0000	.0040	1.95	.0500	.0000	5.1	-
8806	Apr. 26	Apr. 27	None.	None.	0.00	10.95	.0000	.0006	1.97	.0700	.0003	4.6	-
8931	May 24	May 26	None.	Cons., fibrous.	0.00	11.15	.0014	.0048	1.97	.0550	.0001	4.3	-
9037	June 27	June 29	Slight.	V. slight.	0.02	11.00	.0012	.0052	1.80	.0500	.0001	4.7	-
9163	July 26	July 28	None.	None.	0.00	12.20	.0014	.0010	2.00	.0400	.0002	5.1	-
9282	Aug. 19	Aug. 22	V. slight.	V. slight.	0.05	11.60	.0036	.0034	2.00	.0400	.0000	5.3	.0150
9453	Sept. 27	Sept. 28	Slight.	None.	0.02	11.50	.0004	.0026	2.01	.0300	.0002	5.4	.0000
9564	Oct. 25	Oct. 26	None.	None.	0.02	11.60	.0030	.0004	2.02	.0450	.0001	5.6	.0000
9704	Nov. 21	Nov. 22	None.	None.	0.00	11.45	.0000	.0026	2.01	.0400	.0000	6.0	.0000
9832	Dec. 21	Dec. 22	None.	None.	0.00	11.60	.0004	.0000	2.14	.0400	.0001	5.5	.0030
Av.	....	....	....	....	0.01	11.44	.0011	.0025	1.99	.0460	.0001	5.2	.0036

Odor, in July, disagreeable; in May and August, unpleasant; in February, faintly vegetable; in other months, none; on heating, the odor was faintly vegetable in May and June, unpleasant in July and August, and distinctly disagreeable and fishy in September. —— The samples were collected from the reservoir, with the exception of Nos. 8540, 8806 and 9832, which were collected from faucets in the first houses supplied from the main leading from the reservoir.

Microscopical Examination of Water from the Distributing Reservoir of the Woburn Water Works.

[Number of organisms per cubic centimeter.]

	1892. Feb.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	27	26	29	28	22	28	26	23	23
Number of sample,	8540	8806	8931	9037	9163	9282	9453	9564	9704	9832
PLANTS.										
Diatomaceæ,	71	1	3,658	11	0	0	pr.	0	1,802	0
Asterionella,	25	0	2	pr.	0	0	pr.	0	0	0
Cyclotella,	4	0	3,656	0	0	0	0	0	1,800	0
Melosira,	0	0	0	7	0	0	0	0	2	0
Synedra,	42	1	0	4	0	0	0	0	pr.	0
Cyanophyceæ. Anabæna,	0	0	0	0	0	pr.	*140	0	0	0
Algæ. Scenedesmus,	0	0	0	0	pr.	22	46	pr.	32	0
Fungi. Crenothrix,	0	0	0	0	0	1	0	0	0	0
TOTAL,	71	1	3,658	11	pr.	23	186	pr.	1,834	0

* Cells.

WOBURN.

Chemical Examination of Water from Horn Pond, Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.	1892.													
8399	Jan. 5	Jan. 6	Distinct.	Cons.	0.30	11.35	2.30	.0140	.0416	.0242	.0174	2.40	.0700	.0007	3.3
8539	Feb. 19	Feb. 20	Slight.	V. slight.	0.20	10.35	2.20	.0246	.0218	.0184	.0034	2.26	.0750	.0003	3.4
8647	Mar. 22	Mar. 23	Distinct.	Cons., green.	0.15	10.65	2.10	.0134	.0274	.0184	.0090	2.01	.1250	.0003	3.3
8804	Apr. 26	Apr. 27	Distinct.	Cons., green.	0.25	8.70	2.55	.0000	.0288	.0160	.0128	1.93	.0950	.0010	2.9
8929	May 24	May 26	Distinct.	Cons.	0.25	8.95	1.80	.0028	.0284	.0178	.0106	1.88	.0700	.0008	3.1
9036	June 27	June 29	Decided, green.	Cons., green.	0.20	9.50	2.25	.0094	.0402	.0214	.0188	2.00	.0280	.0022	2.8
9161	July 26	July 28	Distinct.	Cons., green.	0.25	10.25	1.95	.0000	.0358	.0222	.0136	2.47	.0020	.0001	3.4
9280	Aug. 19	Aug. 22	Distinct, green.	Slight, green.	0.12	11.05	2.30	.0000	.0304	.0194	.0110	2.67	.3500	.0009	3.1
9451	Sept. 27	Sept. 28	Decided, green.	Slight, green.	0.15	11.05	1.95	.0062	.0536	.0260	.0276	2.80	.0150	.0007	3.5
9562	Oct. 25	Oct. 26	Slight.	Cons.	0.20	11.45	2.05	.0100	.0310	.0232	.0078	2.90	.0300	.0010	3.5
9703	Nov. 21	Nov. 22	Distinct, milky.	Slight, green.	0.50	11.75	2.05	.0402	.0394	.0262	.0132	2.88	.0450	.0007	3.5
9830	Dec. 21	Dec. 22	Distinct, brown.	Cons., brown.	0.45	11.80	2.00	.0116	.0512	.0260	.0252	2.88	.0800	.0007	3.4
Av.	....	....	....	....	0.25	10.57	2.13	.0110	.0358	.0216	.0142	2.42	.0821	.0008	3.3

Odor, vegetable and frequently unpleasant or disagreeable. —— The samples were collected from the pond, one foot beneath the surface, near the pumping station of the Woburn Water Works.

Microscopical Examination of Water from Horn Pond, Woburn.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	7	23	24	27	26	29	28	22	28	26	23	23
Number of sample,	8399	8539	8647	8804	8929	9036	9161	9280	9451	9562	9703	9830
PLANTS.												
Diatomaceæ,	**1,803**	**2,120**	**6,432**	**7,038**	**2,359**	**3,004**	**6**	**25**	**6**	**313**	**258**	**464**
Asterionella,	312	776	4,352	2,280	1,104	1	0	0	2	216	256	5
Cyclotella,	414	352	0	9	172	56	0	0	0	0	0	0
Diatoma,	528	440	1,128	2,756	372	0	0	0	0	42	6	448
Fragilaria,	89	20	16	80	120	2,944	4	0	0	12	0	0
Melosira,	220	122	432	29	136	0	0	0	0	32	0	5
Meridion,	2	0	0	4	0	0	0	0	0	0	0	0
Navicula,	6	0	0	4	2	0	0	1	0	0	0	0
Synedra,	232	408	0	1,876	452	2	2	24	2	11	2	6
Tabellaria,	pr.	2	504	0	1	1	0	0	2	0	0	0

WOBURN.

Microscopical Examination of Water from Horn Pond, Woburn — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,	**5**	**7**	**0**	**0**	**13**	**338**	**606**	**520**	**763**	**11**	**13**	**0**
Anabæna,	0	0	0	0	13	5	0	312	192	0	0	0
Aphanocapsa,	0	0	0	0	0	7	2	0	60	1	0	0
Chroöcoccus,	3	7	0	0	0	16	0	0	186	0	0	0
Clathrocystis,	2	0	0	0	0	304	604	208	1	10	13	0
Cœlosphærium,	0	0	0	0	0	6	0	0	0	0	0	0
Nostoc spores,	0	0	0	0	0	0	0	0	324	0	0	0
Algæ,	**63**	**15**	**16**	**54**	**90**	**1,289**	**123**	**66**	**51**	**17**	**12**	**4**
Botryococcus,	1	1	0	0	0	0	4	0	0	0	0	0
Chlorococcus,	16	4	0	8	9	864	6	52	1	0	1	0
Cosmarium,	0	2	0	0	2	17	100	8	0	2	0	0
Dictyosphærium,	0	0	0	16	0	0	0	0	0	0	0	0
Protococcus,	0	0	0	0	0	2	0	0	0	8	0	0
Raphidium,	2	2	16	20	14	10	0	0	0	0	0	0
Scenedesmus,	6	6	0	9	64	392	13	5	30	6	9	4
Staurastrum,	0	0	0	0	1	2	0	1	20	1	2	0
Zoöspores,	38	0	0	1	0	2	0	0	0	0	0	0
Fungi. Crenothrix,	**0**	**15**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**0**	**0**	**1**
ANIMALS												
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**17**	**0**	**1**	**0**	**1**	**2**	**2**
Actinophrys,	0	0	0	0	0	17	0	0	0	0	0	0
Difflugia,	0	0	0	0	0	0	0	1	0	1	2	2
Infusoria,	**8**	**0**	**12**	**12**	**5**	**4**	**0**	**3**	**1**	**26**	**4**	**0**
Chloromonas,	0	0	0	0	0	0	0	0	0	0	2	0
Cryptomonas,	8	0	0	0	0	0	0	0	0	0	0	0
Encysted protozoan,	0	0	0	0	0	2	0	0	0	0	0	0
Epistylis,	0	0	0	0	0	0	0	0	0	20	0	0
Monas,	0	0	4	12	0	0	0	0	0	0	1	0
Peridinium,	0	0	0	0	1	0	0	0	0	3	1	0
Trachelomonas,	0	0	8	0	4	2	0	3	1	3	0	0
Vermes,	**0**	**0**	**0**	**0**	**8**	**1**	**0**	**4**	**0**	**6**	**1**	**0**
Anurea,	0	0	0	0	8	1	0	2	0	1	0	0
Rotatorian ova,	0	0	0	0	0	0	0	0	0	5	1	0
Triarthra,	0	0	0	0	0	0	0	2	0	0	0	0
Crustacea,	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**.01**	**.20**	**0**
Bosmina,	0	0	0	0	0	0	0	0	0	.01	.20	0
Entomostracan ova,	0	0	0	0	4	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	194	1	0	1	92	116	72	0	0	184	11	9
TOTAL,	2,073	2,158	6,460	7,105	2,572	4,769	807	619	823	558	301	480

WATER SUPPLY OF WORCESTER.

LEICESTER SUPPLY. — *Chemical Examination of Water from the Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.														
8423	Jan. 14	Jan. 15	Slight.	Slight, earthy.	0.30	3.75	1.90	.0056	.0102	.0086	.0016	.14	.0250	.0000	0.8
8545	Feb. 22	Feb. 23	V. slight.	V. slight.	0.30	3.40	1.05	.0056	.0132	.0108	.0024	.18	.0200	.0001	0.8
8639	Mar. 18	Mar. 19	Slight.	V. slight.	0.20	3.10	1.35	.0056	.0134	.0110	.0024	.18	.0200	.0000	0.8
8758	Apr. 19	Apr. 20	Distinct.	Slight.	0.12	2.40	1.05	.0002	.0136	.0102	.0034	.14	.0150	.0001	0.6
8905	May 17	May 18	V. slight.	Slight.	0.10	2.85	0.90	.0002	.0130	.0092	.0038	.14	.0120	.0000	0.6
8996	June 14	June 15	Slight.	Slight, green.	0.10	2.80	0.70	.0000	.0116	.0096	.0020	.16	.0030	.0001	0.3
9128	July 19	July 20	V. slight.	Slight, white.	0.08	2.85	1.00	.0000	.0128	.0106	.0022	.16	.0000	.0000	0.9
9260	Aug. 16	Aug. 17	V. slight.	Cons.	0.10	2.80	1.15	.0000	.0170	.0136	.0034	.13	.0050	.0000	0.5
9402	Sept. 20	Sept 21	Distinct.	Slight.	0.15	2.95	1.40	.0000	.0154	.0128	.0026	.15	.0000	.0000	0.6
9543	Oct. 18	Oct. 19	V. slight.	Slight.	0.45	2.50	0.75	.0084	.0122	.0098	.0024	.15	.0070	.0000	1.0
9674	Nov. 15	Nov. 16	Slight.	Slight.	0.50	2.90	1.20	.0090	.0168	.0126	.0042	.15	.0090	.0000	1.1
9788	Dec. 13	Dec. 14	Slight.	Slight.	0.55	3.55	1.35	.0114	.0180	.0164	.0016	.15	.0100	.0000	1.8
Av.	....	....	....	....	0.25	2.99	1.15	.0038	.0139	.0113	.0026	.15	.0105	.0000	0.8

Odor, faintly vegetable, very seldom mouldy or unpleasant, sometimes none. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface. For heights of water at times when samples were collected, see page 272.

LEICESTER SUPPLY. — *Microscopical Examination of Water from the Lynde Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	16	24	19	20	19	15	20	17	21	20	16	14
Number of sample,	8423	8545	8639	8758	8905	8996	9128	9260	9402	9543	9674	9788
PLANTS.												
Diatomaceæ,	**1**	**1**	**1**	**8**	**32**	**7**	**70**	**24**	**47**	**46**	**29**	**11**
Asterionella,	0	0	0	6	6	0	0	0	14	0	22	5
Cyclotella,	0	pr.	0	2	0	5	70	24	21	6	1	0
Melosira,	0	0	0	0	15	0	0	0	12	37	4	6
Synedra,	1	1	1	0	11	2	0	pr.	0	3	2	pr.
Cyanophyceæ,	**0**	**4**	**0**	**0**	**0**	**8**	**1,096**	**41**	**21**	**78**	**1**	**0**
Anabæna,	0	0	0	0	0	0	0	0	2	3	1	0
Chroöcoccus,	0	4	0	0	0	0	1,096	41	6	75	0	0
Microcystis,	0	0	0	0	0	0	0	0	13	pr.	0	0
Nostoc,	0	0	0	0	0	8	0	0	0	0	0	0
Algæ,	**5**	**2**	**6**	**4**	**0**	**2,557**	**2**	**27**	**22**	**152**	**199**	**0**
Chlorococcus,	5	0	6	0	0	2,556	0	12	2	pr.	12	0
Cosmarium,	0	0	0	0	0	1	2	3	4	1	0	0
Protococcus,	0	0	0	0	0	0	0	0	4	150	184	0
Raphidium,	0	0	0	0	0	0	0	12	3	0	0	0
Staurogenia,	0	0	0	0	0	0	0	0	9	1	2	0
Zoöspores,	0	2	0	4	0	0	0	0	0	0	1	0

WORCESTER.

LEICESTER SUPPLY. — *Microscopical Examination of Water from the Lynde Brook Storage Reservoir* — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**1**	**1**	**pr.**	**4**	**0**
Actinophrys,	0	0	0	0	pr.	0	0	1	1	pr.	2	0
Arcella,	0	0	0	0	0	0	0	0	0	0	2	0
Infusoria,	**8**	**50**	**201**	**14**	**0**	**2**	**1**	**13**	**266**	**2**	**0**	**1**
Codonella,	0	0	0	2	0	0	0	0	0	0	0	0
Dinobryon,	8	45	200	0	0	0	0	0	216	0	0	0
Dinobryon cases,	pr.	5	0	0	0	0	0	12	49	0	0	0
Peridinium,	0	pr.	1	12	0	pr.	1	1	1	pr	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	pr.	2	0	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	1
Vorticella,	0	0	0	0	0	2	0	0	0	0	0	0
Vermes,	**0**	**0**	**pr.**	**0**	**0**	**0**	**1**	**0**	**1**	**pr.**	**0**	**pr.**
Anurea,	0	0	pr.	0	0	0	0	0	1	0	0	pr.
Polyarthra,	0	0	0	0	0	0	1	0	0	pr.	0	0
Miscellaneous. Zoöglœa,	**86**	**1**	**0**	**50**	**10**	**0**	**0**	**12**	**6**	**10**	**62**	**0**
TOTAL,	100	58	208	76	42	2,574	1,170	118	364	288	295	12

HOLDEN SUPPLY. — *Chemical Examination of Water from Tatnuck Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8421	Jan. 14	Jan. 15	V. slight.	V. slight.	0.30	3.20	1.60	.0000	.0090	.0082	.0008	.12	.0150	.0000	0.5
8546	Feb. 22	Feb. 23	V. slight.	V. slight.	0.20	2.70	0.75	.0008	.0092	.0076	.0016	.14	.0180	.0000	0.5
8640	Mar. 18	Mar. 19	Slight.	Slight.	0.10	2.45	1.15	.0104	.0086	.0080	.0006	.15	.0140	.0000	0.6
8759	Apr. 19	Apr. 20	Distinct.	Slight.	0.12	2.00	0.80	.0000	.0086	.0058	.0028	.12	.0050	.0001	0.3
8904	May 17	May 18	Slight.	Cons., green.	0.10	3.10	1.25	.0000	.0146	.0094	.0052	.13	.0030	.0000	0.5
8997	June 14	June 15	Slight.	Slight, white.	0.12	2.80	0.80	.0000	.0112	.0090	.0022	.11	.0000	.0000	0.1
9127	July 19	July 20	Slight.	Slight.	0.10	2.15	0.70	.0002	.0136	.0096	.0040	.12	.0000	.0000	0.5
9259	Aug. 16	Aug. 17	Slight.	Cons., green.	0.12	2.30	1.00	.0000	.0144	.0106	.0038	.10	.0050	.0000	0.7
9286	Aug. 22	Aug. 23	Slight.	Cons.	0.10	1.90	0.70	.0002	.0176	.0130	.0046	.10	.0000	.0000	0.2
9403	Sept 20	Sept. 21	Decided.	Cons.	0.15	2.25	1.00	.0008	.0180	.0140	.0040	.11	.0000	.0000	0.3
9542	Oct. 18	Oct. 19	Distinct.	Slight, green.	0.35	1.90	0.95	.0000	.0180	.0138	.0042	.11	.0090	.0001	0.5
9675	Nov. 15	Nov. 16	Slight.	Slight.	0.35	2.60	1.15	.0000	.0186	.0162	.0024	.12	.0090	.0000	1.0
9789	Dec. 13	Dec. 14	Distinct.	Slight.	0.40	3.00	1.30	.0022	.0242	.0218	.0024	.14	.0050	.0001	0.5
Av.	....	....	....	....	0.20	2.52	1.03	.0012	.0142	.0113	.0029	.12	.0067	.0000	0.5

Odor, in the first eight months, generally distinctly vegetable and unpleasant; in the last four months, very faintly vegetable or none. —— Nos. 8421, 8546, 8759 and 8904 were collected at the foot of the overflow below the reservoir; Nos. 8640 and 9259 were collected from the lower end of a thirty-inch pipe through the dam, and represent water drawn from the bottom of the reservoir; the remaining samples were collected from the reservoir near the gate-house, one foot beneath the surface.

WORCESTER,

HOLDEN SUPPLY.—*Microscopical Examination of Water from Tatnuck Brook Storage Reservoir.*

[Number of organisms per cubic centimeter.]

	1892.												
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	16	24	19	20	19	15	20	17	24	21	20	16	14
Number of sample,	8421	8546	8640	8759	8904	8997	9127	9259	9286	9403	9542	9675	9789
PLANTS.													
Diatomaceæ,	**53**	**11**	**23**	**461**	**1,389**	**25**	**253**	**938**	**2,311**	**2,771**	**1,363**	**618**	**45**
Asterionella,	43	1	0	0	8	1	93	3	7	12	4	28	12
Cyclotella,	pr.	0	0	0	64	0	1	0	0	0	2	0	0
Diatoma,	0	0	0	13	1	0	0	500	2,032	2,444	5	0	0
Melosira,	4	0	7	206	866	19	56	114	98	35	238	382	21
Navicula,	0	1	pr.	pr.	2	0	3	0	1	0	3	3	0
Synedra,	3	6	12	146	0	0	4	1	1	8	3	5	4
Tabellaria,	3	3	4	96	448	5	96	320	172	272	1,108	200	8
Cyanophyceæ,	**0**	**0**	**0**	**0**	**1**	**pr.**	**0**	**5**	**9**	**14**	**84**	**0**	**0**
Aphanocapsa,	0	0	0	0	1	0	0	5	7	14	2	0	0
Chroöcoccus,	0	0	0	0	0	pr.	0	0	2	0	82	0	0
Algæ,	**1**	**0**	**3**	**3**	**28**	**0**	**0**	**22**	**119**	**40**	**142**	**8**	**8**
Chlorococcus,	1	0	0	0	16	0	0	8	68	0	12	0	0
Conferva,	pr.	0	3	3	0	0	0	0	1	0	22	0	0
Dictyosphærium,	0	0	0	0	3	0	0	0	0	0	0	0	8
Hyalotheca,	0	0	0	0	0	0	0	4	5	0	19	6	0
Pediastrum,	0	0	0	0	1	0	0	0	1	2	2	0	0
Protococcus,	0	0	0	0	0	0	0	0	0	8	0	0	0
Raphidium,	0	0	0	0	2	0	0	3	1	2	68	0	0
Scenedesmus,	pr.	0	0	0	6	0	0	pr.	1	0	3	2	0
Sphærozosma,	0	0	0	0	0	0	0	0	0	0	11	0	0
Staurastrum,	0	0	0	0	pr.	0	0	7	42	28	5	0	0
Fungi. Crenothrix,	**2**	**1**	**5**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
ANIMALS.													
Infusoria,	**1**	**0**	**5**	**148**	**68**	**4**	**172**	**46**	**31**	**9**	**5**	**0**	**0**
Dinobryon,	pr.	0	pr.	148	0	0	0	0	0	0	0	0	0
Peridinium,	1	0	5	pr.	68	4	172	46	30	9	5	0	0
Trachelomonas,	0	0	0	0	pr.	0	0	0	1	0	pr.	0	0
Vermes,	**0**	**0**	**1**	**0**	**1**	**pr.**	**2**	**pr.**	**0**	**0**	**pr.**	**1**	**0**
Anurea,	0	0	1	0	1	pr.	0	pr.	0	0	0	1	0
Polyarthra,	0	0	0	0	0	pr.	2	0	0	0	pr.	0	0
Crustacea. Cyclops,	**0**	**0**	**0**	**0**	**0**	**.01**	**0**	**0**	**.07**	**.01**	**.03**	**0**	**0**
Miscellaneous. Zoöglœa,	**2**	**9**	**0**	**148**	**2**	**0**	**11**	**128**	**124**	**56**	**160**	**90**	**3**
TOTAL,	59	21	37	760	1,490	29	438	1, 0	2,594	2,890	1,754	717	56

WORCESTER.

Record of Height of Water in Leicester and Holden Storage Reservoirs at Times when Samples of Water were collected for Analysis.

NOTE.—Leicester Reservoir, height of rollway, 37.40 feet; Holden Reservoir, height of rollway, 20.10 feet.

DATE.	Height of Water.		DATE.	Height of Water.	
	Leicester.	Holden.		Leicester.	Holden.
1892.	Feet.	Feet.	1892.	Feet.	Feet.
Jan. 14,	30.25	20.28	July 19,	34.42	18.20
Feb. 22,	32.80	20.94	Aug. 16,	33.70	17.30
Mar. 18,	33.83	20.18	Sept. 20,	32.02	15.96
Apr. 19,	35.50	20.10	Oct. 18,	29.50	13.42
May 17,	35.35	20.34	Nov. 15,	27.85	8.60
June 14,	36.50	19.90	Dec. 13,	28.95	8.00

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

There have been made during the past year regular monthly examinations of the waters of the Blackstone, Merrimack, Taunton, Ipswich, Stillwater and Quinepoxet rivers, special examination of the tidal portion of Charles River, and occasional examinations of other rivers in the State. Most of the results of these examinations will be found arranged alphabetically by rivers in the pages which follow, except that the Stillwater and Quinepoxet rivers will be found under the head of the Nashua River, of which they are tributaries. Some of the results, however, are printed on preceding pages, in connection with the water supplies, under the head of the towns where the samples were collected, as follows: —

Charles River at Medfield,	Page 184
Charles River at Watertown,	" 253
Merrimack River at Lawrence,	" 149
Merrimack River at Lowell,	" 157
Merrimack River at Newburyport,	" 195
Miles River at Ipswich,	" 147
Neponset River at Hyde Park,	" 146
Taunton River at Taunton,	" 242

Blackstone River.

The last annual report of the Board contained, in addition to the regular monthly analyses of this river at four points, the results of an extended special examination of the river at various points, and of the sewage and effluent from the Worcester Sewage Precipitation Works. During the year 1892, the regular monthly examinations were continued, but no special examinations were made. There have been no very important changes with regard to the amount of sewage treated at the precipitation works, and by far the larger part of the sewage of Worcester goes directly into the river without treatment. The construction of ten tanks at the precipitation works, in addition to the six now in use, was far advanced toward completion at the end of the year, and it is expected that these tanks will be used to treat a much larger proportion of the sewage in 1893 than heretofore.

BLACKSTONE RIVER.

The monthly examinations of the river have been continued without interruption since June, 1887, and the average results for each calendar year and for the six months of each year from June to November are given in tables which follow, as well as the detailed analyses made during the year 1892.

Averages of Chemical Analyses of Water from the Blackstone River for the Years 1888 to 1892, inclusive.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dissolved.	Sus-pended.				
1888,	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889,	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890,	0.82	-	-	.1800	.1024	.0549	.0475	1.03	.0367	.0014	-
1891,	0.80	13.54	4.00	.3340	.1563	.0840	.0723	1.73	.0333	.0032	4.6
1892,	0.71	16.28	4.85	.2530	.1262	.0627	.0635	1.84	.0312	.0061	4.9

Blackstone River below Sewage Precipitation Works.

1888,	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889,	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890,	0.74	-	-	.2253	.1177	.0581	.0596	1.26	.0381	.0016	-
1891,	0.80	15.62	4.52	.4080	.1303	.0695	.0608	1.91	.0358	.0031	4.6
1892,	0.53	19.35	5.29	.3633	.1442	.0737	.0705	2.21	.0278	.0033	7.2

Blackstone River at Uxbridge.

1888,	0.45	-	-	.0979	.0284	-	-	0.61	.0322	.0008	-
1889,	0.28	-	-	.0992	.0300	.0191	.0109	0.60	.0253	.0009	-
1890,	0.25	-	-	.1168	.0214	.0152	.0062	0.66	.0272	.0006	-
1891,	0.27	8.32	1.94	.1647	.0272	.0197	.0075	0.77	.0396	.0008	2.8
1892,	0.21	8.59	1.90	.2113	.0222	.0153	.0069	0.82	.0326	.0007	2.8

Blackstone River at Millville

1888,	0.47	-	-	.0444	.0253	-	-	0.44	.0242	.0005	-
1889,	0.38	-	-	.0450	.0277	.0206	.0071	0.43	.0160	.0004	-
1890,	0.34	-	-	.0587	.0211	.0162	.0049	0.46	.0240	.0004	-
1891,	0.32	6.05	1.83	.0807	.0293	.0194	.0099	0.55	.0275	.0005	1.9
1892,	0.35	6.03	1.62	.0896	.0249	.0180	.0069	0.54	.0218	.0004	1.8

BLACKSTONE RIVER.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1892.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

MONTHS.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dissolved.	Suspended.				
June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892,	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1

Blackstone River below Sewage Precipitation Works.

June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891,	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892,	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3

Blackstone River at Uxbridge.

June-Nov., 1887,	0.39	-	-	.1129	.0271	-	-	0.79	.0360	-	-
" " 1888,	0.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	-
" " 1889,	0.32	-	-	.1133	.0296	.0192	.0104	0.66	.0333	.0009	-
" " 1890,	0.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891,	0.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892,	0.13	9.36	1.88	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1

Blackstone River at Millville.

June-Nov., 1887,	0.31	-	-	.0468	.0220	-	-	0.51	.0210	-	-
" " 1888,	0.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	-
" " 1889,	0.38	-	-	.0499	.0273	.0213	.0060	0.45	.0167	.0003	-
" " 1890,	0.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891,	0.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892,	0.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River between

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1892.										
1	8416	Jan. 12	Jan. 13	Decided.	Heavy.	1.60	-	15.10	-	-	5.75	-
2	8531	Feb. 17	Feb. 19	Decided.	Heavy.	0.45	-	9.95	-	-	3.95	-
3	8631	Mar. 16	Mar. 17	Decided.	Heavy.	-	-	12.55	-	-	2.20	-
4	8773	Apr. 20	Apr. 21	Decided.	Heavy.	0.15	-	8.25	-	-	1.95	-
5	8917	May 18	May 19	Decided.	Heavy.	0.80	-	9.15	-	-	2.60	-
6	9007	June 15	June 16	Decided.	Heavy.	0.60	-	12.80	-	-	3.50	-
7	9134	July 20	July 20	Decided.	Heavy, brown.	0.40	-	16.90	-	-	3.90	-
8	9267	Aug. 17	Aug. 18	Distinct, milky.	Heavy, rusty.	0.00	30.90	23.70	7.20	9.80	6.70	3.10
9	9419	Sept. 21	Sept. 23	Decided, milky.	Heavy, dark.	0.60	-	27.50	-	-	11.20	-
10	9552	Oct. 20	Oct. 22	Decided.	Heavy, brown.	0.50	42.70	29.10	13.60	16.40	8.00	8.40
11	9687	Nov. 16	Nov. 17	Decided.	Heavy, dark.	1.00	29.30	14.50	14.80	8.10	4.50	3.60
12	9797	Dec. 14	Dec. 15	Decided.	Heavy, dark.	1.70	21.80	15.90	5.90	8.20	4.00	4.20
13	Av..	....	....	....	....	0.71	-	16.28	-	-	4.85	-

Odor, offensive. —— The samples were collected from the river, about two hundred feet below the iron bridge. All but two of the samples were collected on Wednesday, the exceptions being Nos. 8416 and 9552, the former of which was collected on Tuesday and the latter on Thursday. Nos. 9134 and 9267 were collected at about 11 A.M.; all others were collected between 2.30 and 4.30 P.M.

Chemical Examination of Water from the Blackstone

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1892.										
1	8417	Jan. 12	Jan. 13	Decided.	Heavy.	1.80	-	11.30	-	-	4.00	-
2	8532	Feb. 17	Feb. 19	Decided.	Heavy.	0.15	-	10.50	-	-	2.75	-
3	8632	Mar. 16	Mar. 17	Decided.	Heavy.	0.55	-	13.75	-	-	2.30	-
4	8774	Apr. 20	Apr. 21	Distinct.	Heavy.	0.15	-	9.35	-	-	2.35	-
5	8918	May 18	May 19	Decided.	Heavy.	0.00	-	10.85	-	-	3.00	-
6	9008	June 15	June 16	Decided.	Heavy.	0.90	-	13.40	-	-	4.10	-
7	9135	July 20	July 20	Decided.	Heavy, brown.	0.55	-	31.90	-	-	9.90	-
8	9268	Aug. 17	Aug. 18	Decided, milky.	Heavy, rusty.	0.00	42.30	33.90	8.40	11.80	8.50	3.30
9	9420	Sept. 21	Sept. 23	Decided, milky.	Heavy, dark.	1.00	-	24.40	-	-	9.30	-
10	9553	Oct. 20	Oct. 22	Decided.	Heavy, brown.	*	53.40	46.80	6.60	17.00	11.40	5.60
11	9688	Nov. 16	Nov. 17	Decided.	Heavy, dark.	0.70	20.10	10.40	9.70	4.80	3.30	1.50
12	9798	Dec. 14	Dec. 15	Decided, rusty.	Heavy, rusty.	0.05	27.20	15.60	11.60	7.00	2.60	4.40
13	Av.	....	....	....	....	0.53	-	19.35	-	-	5.29	-

Odor, offensive. —— The samples were collected from the river, above Millbury and below the point where the effluent from the Worcester Precipitation Works enters the river. All but two of the samples were collected on Wednesday, the exceptions being Nos. 8417 and 9553, the former of which was collected on Tuesday and the latter on Thursday. Nos. 9135 and 9268 were collected at about 11.00 A.M.; all others between 2.40 and 4.40 P.M.

* This sample was nearly colorless when received, but after standing two days the color became 0.65.

BLACKSTONE RIVER.

Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.		
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		Unfiltered.	Filtered.	
.1280	.1110	.0460	.0650	1.33	.0450	.0020	4.9	-	-	1
.1000	.1030	.0550	.0480	.82	.0550	.0025	2.2	-	-	2
.1120	.0850	.0440	.0410	1.36	.0600	.0008	4.0	-	-	3
.1400	.1160	.0440	.0720	1.32	.0220	.0015	2.6	-	-	4
.1680	.1000	.0450	.0550	.98	.0350	.0010	2.9	-	-	5
.2080	.1290	.0400	.0890	1.90	.0050	.0120	3.0	-	-	6
.5200	.1120	.0580	.0540	1.28	.0100	.0200	7.0	-	-	7
.1360	.0640	.0320	.0320	2.20	.0070	.0003	10.7	-	-	8
.3440	.2120	.0720	.1400	2.06	.0090	.0001	4.1	.7600	.3200	9
.6800	.2410	.1650	.0760	5.60	.0100	.0300	8.4	4.2000	1.4000	10
.2400	.1020	.0580	.0440	1.56	.0950	.0024	3.6	2.1000	.4000	11
.2600	.1400	.0930	.0470	1.65	.0220	.0010	5.0	1.2750	.4300	12
.2530	.1262	.0627	.0635	1.84	.0312	.0061	4.9	-	-	13

Microscopical Examination.

The principal organisms observed were *Zoöglœa* and *Saccharomyces*, the former being exceedingly abundant.

River below the Worcester Precipitation Works.

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.		
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		Unfiltered.	Filtered.	
.1360	.0940	.0540	.0400	1.06	.0520	.0022	2.7	-	-	1
.2000	.1100	.0610	.0490	1.21	.0550	.0030	2.5	-	-	2
.1400	.0780	.0480	.0300	1.50	.0650	.0007	4.9	-	-	3
.2000	.1290	.0550	.0740	1.54	.0200	.0014	2.2	-	-	4
.2000	.1000	.0290	.0710	1.18	.0350	.0015	4.3	-	-	5
.2440	.1650	.0730	.0920	1.56	.0070	.0000	3.0	-	-	6
.6400	.2290	.1600	.0690	2.89	.0100	.0100	14.9	-	-	7
.8000	.1960	.1130	.0830	5.00	.0100	.0002	14.1	-	-	8
.4000	.2400	.0760	.1640	2.33	.0070	.0001	5.4	.8600	.2700	9
.9000	.1680	.1070	.0610	6.00	.0100	.0180	21.7	10.8000	9.8000	10
.1600	.0880	.0460	.0420	1.01	.0380	.0018	2.6	1.2000	.2900	11
.3400	.1330	.0620	.0710	1.30	.0250	.0010	7.7	1.6800	.9000	12
.3633	.1442	.0737	.0705	2.21	.0278	.0033	7.2	-	-	13

Microscopical Examination.

The principal organisms observed were *Zoöglœa* and *Saccharomyces*, the former being exceedingly abundant.

BLACKSTONE RIVER.

Chemical Examination of Water from the Blackstone River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8419	Jan. 13	Jan. 13	Distinct.	Heavy, rusty.	0.05	8.40	2.65	.0880	.0280	.0150	.0130	.61	.0500	.0002	2.6
8525	Feb. 18	Feb. 18	Distinct, milky.	V. slight.	0.08	7.55	2.25	.1280	.0190	.0140	.0050	.60	.0400	.0012	2.5
8617	Mar. 16	Mar. 16	Distinct, milky.	Slight.	1.10	7.10	2.00	.0720	.0260	.0170	.0090	.49	.0450	.0005	2.0
8775	Apr. 21	Apr. 21	Slight, milky.	Slight.	0.05	7.15	1.35	.1280	.0070	.0040	.0030	.64	.0180	.0008	2.0
8919	May 19	May 19	Decided.	Cons.	0.40	7.55	1.50	.2080	.0080	.0040	.0040	.75	.0250	.0010	2.5
9013	June 15	June 16	Slight.	Cons.	0.15	7.50	1.85	.1560	.0300	.0240	.0060	.64	.0150	.0012	2.6
9136	July 21	July 21	Slight.	Cons.	0.20	8.05	1.75	.1680	.0190	.0150	.0040	1.04	.0500	.0006	2.6
9269	Aug. 18	Aug. 18	Decided.	Slight, dark.	0.15	9.00	1.90	.3000	.0230	.0140	.0090	1.20	.0300	.0005	3.4
9470	Sept. 29	Sept. 30	Slight, milky.	Slight, rusty.	0.08	9.75	1.60	.3200	.0100	.0040	.0060	1.07	.0450	.0002	3.0
9605	Nov. 2	Nov. 2	Slight, milky.	Slight.	0.08	11.60	1.90	.4800	.0210	.0130	.0080	1.21	.0280	.0003	3.6
9686	Nov. 17	Nov. 17	Decided, rusty.	Slight, rusty.	0.15	10.25	2.30	.2800	.0330	.0270	.0060	.81	.0200	.0013	3.4
9801	Dec. 15	Dec. 15	Distinct, milky.	Cons., rusty.	0.00	9.15	1.75	.2080	.0280	.0210	.0070	.78	.0250	.0003	3.4
Av.	....	....	....	....	0.21	8.59	1.90	.2113	.0222	.0153	.0069	.82	.0326	.0007	2.8

Odor, musty and very frequently offensive; on heating, the odor is less strong.——The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill just before the water passes the screens. The amount of iron was determined in the last four samples, and was found to be as follows, in parts per 100,000: No. 9470, .0230; No. 9605, .0160; No. 9686, .0550; No. 9801, .0840.

Microscopical Examination of Water from the Blackstone River at Uxbridge.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Nov.	Dec.
Day of examination,	14	19	17	23	21	16	21	19	30	3	17	16
Number of sample,	8419	8525	8617	8775	8919	9013	9136	9269	9470	9605	9686	9801
PLANTS.												
Diatomaceæ,	**2**	**0**	**0**	**8**	**18**	**3**	**72**	**35**	**0**	**63**	**2**	**0**
Diatoma,	0	0	0	0	0	2	7	7	0	59	2	0
Synedra,	2	0	0	4	11	1	60	26	0	4	0	0
Tabellaria,	0	0	0	4	7	0	5	2	0	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**3**	**pr.**	**15**	**50**	**0**	**4**	**2**	**0**
Chlorococcus,	0	0	0	0	3	0	0	15	0	0	2	0
Pandorina,	0	0	0	0	0	0	8	pr.	0	0	0	0
Protococcus,	0	0	0	0	0	0	0	9	0	0	0	0
Scenedesmus,	0	0	0	0	0	pr.	0	26	0	0	0	0
Spirogyra,	0	0	0	0	0	0	7	0	0	4	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**40**	**0**	**0**	**0**

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River at Uxbridge — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Nov.	Nov.	Dec.
ANIMALS.												
Infusoria,	1	0	0	12	0	26	369	268	0	208	2	0
Dinobryon,	1	0	0	9	0	26	0	112	0	208	0	0
Dinobryon cases,	0	0	0	0	0	0	316	134	0	0	0	0
Peridinium,	0	0	0	3	0	pr.	52	20	0	0	0	0
Phacus,	0	0	0	0	0	0	1	pr.	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	2	0	0	2	0
Vermes,	0	0	0	0	0	0	1	2	0	0	0	0
Anurea,	0	0	0	0	0	0	0	2	0	0	0	0
Rotatorian ova,	0	0	0	0	0	0	1	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	540	1,158	150	444	198	76	248	320	*	156	512	208
TOTAL,	543	1,158	150	464	219	105	705	675	-	431	518	208

* Abundant.

Chemical Examination of Water from the Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
8424	Jan. 15	Jan. 16	Distinct, milky.	Slight, rusty.	0.70	5.55	2.00	.0472	.0208	.0156	.0052	.37	.0200	.0003	0.8
8542	Feb. 22	Feb. 23	Decided.	Slight.	0.20	6.20	1.85	.0800	.0214	.0170	.0044	.53	.0350	.0007	2.2
8646	Mar. 22	Mar. 23	Distinct, clayey.	Slight.	0.25	4.50	1.35	.0312	.0156	.0124	.0032	.37	.0250	.0010	1.3
8793	April 23	April 23	Distinct.	Slight.	0.20	5.15	1.70	.0640	.0262	.0184	.0078	.42	.0100	.0003	1.6
8920	May 19	May 20	Distinct.	Cons., rusty.	0.20	5.05	1.40	.0880	.0236	.0148	.0088	.44	.0220	.0005	1.7
9021	June 18	June 20	V slight	Slight.	0.55	5.55	1.50	.0768	.0256	.0214	.0042	.44	.0100	.0003	1.4
9205	Aug. 6	Aug. 8	Distinct, milky.	Slight, rusty.	0.30	7.05	1.45	.1568	.0202	.0168	.0034	.88	.0300	.0003	2.1
9284	Aug. 20	Aug. 22	Slight.	Slight.	0.30	6.50	1.50	.0710	.0302	.0274	.0028	.65	.0250	.0003	2.3
9424	Sept. 22	Sept. 23	Slight.	Slight.	0.25	7.80	2.00	.1154	.0336	.0246	.0090	.75	.0280	.0002	2.2
9548	Oct. 20	Oct. 22	Slight.	Slight.	0.25	6.20	1.50	.0660	.0226	.0178	.0048	.57	.0070	.0002	1.9
9690	Nov. 17	Nov. 19	Distinct, milky.	Slight, rusty.	0.60	7.10	1.75	.2000	.0440	.0180	.0260	.49	.0300	.0000	2.1
9804	Dec. 16	Dec. 17	Slight, milky.	Slight.	0.40	5.70	1.50	.0784	.0156	.0120	.0036	.60	.0200	.0003	1.6
Av.	....	....	....	....	0.35	6.03	1.62	.0896	.0249	.0180	.0069	.54	.0218	.0004	1.8

Odor, generally musty, occasionally disagreeable or offensive. —— The samples were collected from the river, just above the dam in the village of Millville. The amount of iron was determined in the last four samples, and was found to be as follows in parts per 100,000: No. 9424, .0290; No. 9548, .0370; No. 9690, .0940; No. 9804, .0475.

BLACKSTONE RIVER.

Microscopical Examination of Water from the Blackstone River at Millville, Blackstone.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	16	24	23	26	21	22	9	22	23	22	18	17
Number of sample,	8424	8542	8646	8793	8920	9021	9205	9284	9424	9548	9690	9804
PLANTS.												
Diatomaceæ,	52	0	61	36	143	17	9	66	61	24	34	4
Asterionella,	4	0	0	pr.	4	0	0	0	10	1	5	2
Diatoma,	0	0	1	2	15	5	3	35	4	2	24	0
Melosira,	0	0	0	13	10	0	0	0	3	8	0	0
Navicula,	1	0	32	0	0	pr.	pr.	1	0	1	5	0
Synedra,	44	0	28	19	107	8	6	30	44	6	2	2
Tabellaria,	3	0	pr.	2	7	4	0	0	0	6	0	0
Algæ,	0	0	0	1	4	2	1	41	1	1	3	0
Chlorococcus,	0	0	0	0	0	0	pr.	36	0	0	1	0
Scenedesmus,	0	0	0	0	0	2	1	5	1	1	2	0
Zoöspores,	0	0	0	1	4	0	pr.	0	0	pr.	0	0
Fungi. Crenothrix,	0	0	pr.	0	16	195	124	118	32	62	6	0
ANIMALS.												
Rhizopoda. Actinophrys,	0	0	0	0	0	1	pr.	pr.	0	0	1	0
Infusoria,	4	0	3	16	39	14	11	313	46	50	16	0
Dinobryon,	4	0	1	14	37	0	5	268	28	40	15	0
Dinobryon cases,	0	0	2	0	0	14	5	42	17	8	1	0
Peridinium,	0	0	pr.	1	1	0	1	3	0	2	0	0
Synura,	0	0	0	1	1	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	pr.	pr.	1	0	0	0
Vermes. Polyarthra,	0	0	0	0	1	pr.	0	pr.	0	0	0	0
Miscellaneous. Zoöglœa,	336	944	314	256	162	222	228	142	156	134	332	260
TOTAL,	392	944	378	309	365	451	373	680	296	271	392	264

Charles River.

The Charles River above the lower dam at Watertown drains an area of 270 square miles; but, as one-third of the flow of the river at East Dedham may be legally diverted through Mother Brook into the Neponset River, the effective drainage area at the Watertown dam is 204 square miles, and the average daily flow in an ordinary year may be reckoned at 340 cubic feet per second. The tidal portion of the river, which has a length of 9.3 miles, extends nearly up to the dam above referred to, and into it is turned a very large amount of

sewage and manufacturing refuse from the cities of Cambridge and Somerville and the Brighton district of the city of Boston.

During the summer of 1892, there were many complaints of the unsanitary condition of the tidal portion of the river, and two series of analyses of its waters were made, with results which may be found in tables which follow. Analyses in this case have a two-fold purpose: first, they show the extent to which the water of different parts of the river is polluted by the sewage turned into it; and, second, the amount of sea water at different points, from which inferences can be drawn as to the distance that polluting matters turned into the lower portion of the river can be carried up stream by the tidal action, and as to the relative amounts of sea and fresh water which mingle with and dilute the sewage, and thus tend to maintain the river in a sanitary condition.

In a tidal river, if the salt water during the rising tide pushed back the fresh water without mingling with it, as if a piston separated the two, the salt water would not as a rule extend very far up from the mouth of the river. It is found, however, that this piston-like action does not occur in practice, as there is always a considerable mingling of the fresh and salt water, even in a river of uniform section, by means of which some of the salt water is carried very much further up stream than it otherwise would be. This mingling action is greatly facilitated where there is a wide estuary, such as exists in the lower third of the tidal portion of the Charles River.

It is obvious that the distance up stream to which the salt water will flow will vary from time to time with the quantity of upland water flowing, and the amount that the tide rises and falls. The greatest distance will be reached during spring tides, accompanied by a minimum flow of upland water, while the least distance will be attained when the neap tides coincide with a maximum flow of upland water. It should also be remarked, as governing the tidal movements in Charles River, that the upper portion of the stream is bordered by marshes which are overflowed by the spring tides, and the quantity of tide water which enters this portion of the river and mingles with the fresh water is therefore greatly increased during such tides.

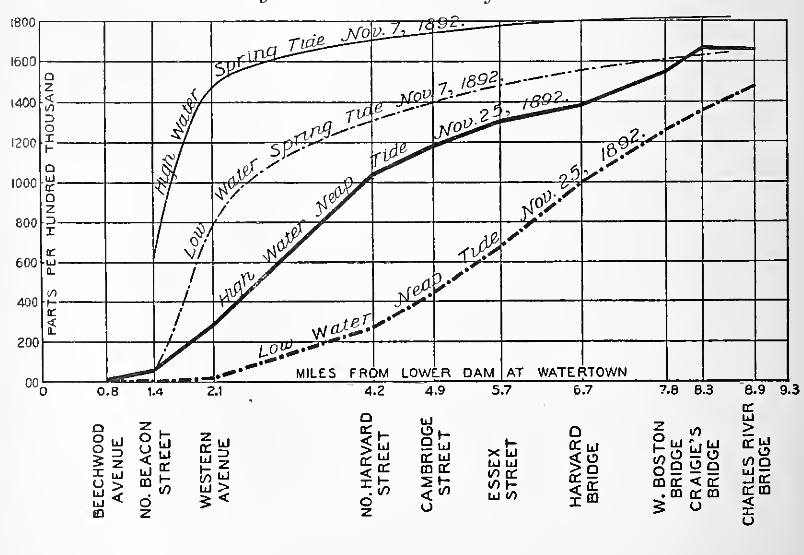
The principal object of the first series of analyses was to determine how far up stream the salt water and consequently the sewage

CHARLES RIVER.

discharged into the lower portions of the river would pass during a high spring tide, occurring at a time when the flow of upland water was small. These observations were consequently made on November 5 and 7, during the highest course of spring tides given in the tide tables for the year, and during the time when the flow of upland water was unusually small. The second series, which was much more extended, was made on November 25, during a course of neap tides, and at a time when the amount of upland water flowing was about half as much as the average during an ordinary year.

The most prominent results of the analyses are shown by the following diagrams, the first showing the amount of chlorine and the second the amount of albuminoid ammonia found at different points along the river, both at high and low water of spring and neap tides. The heavier lines indicate the results obtained during the neap tide, when samples were collected from many points, and the lighter lines the results obtained during the spring tide, when but few samples were collected. The lighter lines, therefore, can be considered as accurate only at the points where samples were collected as indicated by the tables of analyses subsequently given.

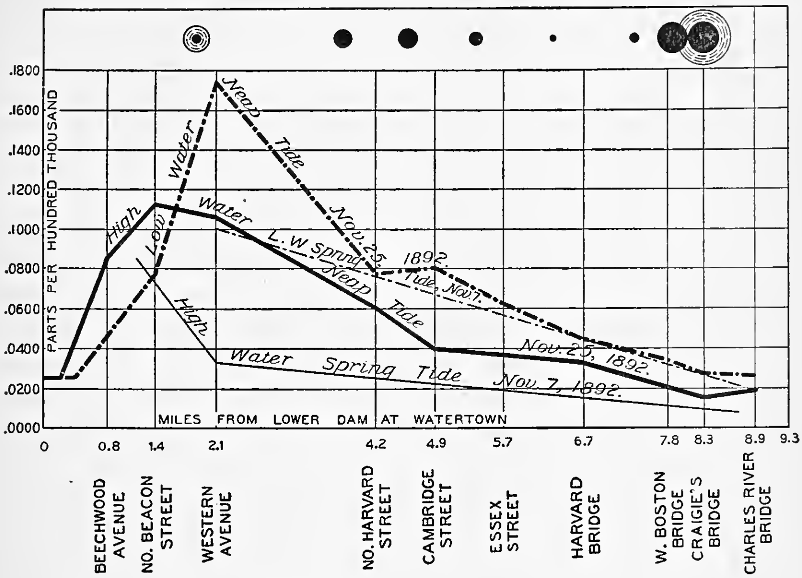
Chlorine Diagram, indicating the Degree of Saltness of the Water at Different Points along the Tidal Portion of Charles River.



CHARLES RIVER.

Albuminoid Ammonia Diagram, indicating the Degree of Pollution of the Water at Different Points along the Tidal Portion of Charles River.

[NOTE. — The circles in the upper part of the diagram indicate by their size the amount of polluting matter entering the river at the different points.]



During the spring tide the amount of chlorine at high water near the mouth of the river was nearly as large as in undiluted sea water, and even as far up as the Western Avenue and North Beacon Street bridges, leading from Brighton to Watertown, the amount of chlorine was respectively 81 and 34 per cent. of the amount at the mouth of the river. These figures show that under the conditions of spring tides and small flow of upland water enough sea water will find its way up to these bridges to materially assist in diluting the sewage turned into the stream in their vicinity. During the high water of the neap tide the salt water did not extend as far up stream, the amount at the Western Avenue bridge above referred to being only about one-sixth as much as at the mouth of the river; but at North Harvard Street more than half the water was sea water, showing that even on the neap tide sea water is an important factor in maintaining the sanitary condition of the river, at times when the flow of fresh water is small, up to or beyond this point.

The albuminoid ammonia diagram, which is given as the best measure of the pollution of the river at different points, shows even

more than the chlorine diagram the extent to which the river depends upon the free entrance of sea water for maintaining its sanitary condition.

The relative amount of sewage entering the river between the different sampling places is indicated by black circles in the upper part of the diagram, the areas of these circles being proportionate to the amount of sewage. In two cases a very large amount of manufacturing wastes is turned into the river, and this fact is indicated upon the diagram by an annular shaded space surrounding the black circle, and intended to indicate roughly the relative amount of pollution by these wastes. It will be observed that, although these circles show that by far the greatest amount of foul matter enters the river toward its mouth, yet the curves of albuminoid ammonia indicate that the water is in the most polluted condition near the upper end of the tidal portion, showing again, and in an emphatic way, the extent to which the lower portion of the river depends for its purification upon the cleansing action of the tide water.

The most offensive odors came from the river when the deposits of sewage matter on the flats and banks were exposed at low tide. These deposits were very offensive near the sewer outlet at Craigie's bridge, from which is discharged not only the sewage of a very large population in Cambridge and Somerville, but also the wastes from two large pork-packing establishments, and near the outlet of the Binney Street sewer, which empties into the river a short distance below the West Boston bridge. Taking the river as a whole, however, the deposits were much deeper and more offensive toward the upper end of the tidal portion, where the tidal currents are weak. Some of these thick deposits were above all sewer outlets, indicating that sewage matter was carried up by the flood tide and deposited.

It is obvious from this investigation that the tidal portion of Charles River is in an unsanitary condition, and that no radical improvement of its condition can be expected until the sewage now entering it is diverted; and this cannot be accomplished, except in Brighton, until that portion of the Metropolitan sewerage system extending from Cambridge to the outlet at Deer Island is completed and put in operation. The Metropolitan sewer on the south side of Charles River was completed and ready to receive sewage in the spring of 1892, and was intended to take all the sewage of

Brighton, but at the end of 1892 most of the sewage of this district and all the wastes from the Brighton Abattoir were being turned directly into the river. The discharge of sewage into the river at Brighton should be stopped without delay, and in Cambridge and Somerville all arrangements for connecting the local sewers with the Metropolitan system should be made in time to permit the sewage of these cities to be turned into the Metropolitan sewer as soon as it is completed.

In the foregoing statements relating to the tidal portion of the Charles River no reference has been made to the sewage and manufacturing wastes which enter the non-tidal portion of the river, for the reason that the amount entering this portion of the stream is small in comparison with the amount which enters below the Watertown dam. The condition of the water in the river above the second dam at Watertown is indicated by an analysis given on page 253 of this report, and by a series of analyses published in the Special Report of the Board upon the Examination of Water Supplies, 1890, page 403.

After the sewage now entering the tidal portion of the river has been wholly diverted by connections with the Metropolitan sewers, it may be necessary, in order to complete the sanitary improvement of the river, to take measures to prevent the exposure of the flats at low tide, and to prevent the entrance of polluting matters into the upper portions of the stream.

Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during High Water of Spring Tides, Nov. 5 and 7, 1892.

[Parts per 100,000.]

Number.	LOCALITY.	Appearance.			Odor.		Residue on Evaporation.	Ammonia.				Chlorine.
									Albuminoid.			
		Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Total.	Dissolved.	Suspended.	
9639	North Beacon St.,	Decided, milky.	Cons.	0.22	Decided, off'nsive.	Decided, off'nsive.	1291.4	.1506	.0730	.0472	.0258	620.0
9634	Western Ave., .	-	-	-	-	-	-	-	-	-	-	1430.0
9638	Western Ave., .	Decided, milky.	Cons.	0.06	Decided, off'nsive.	Decided, musty.	3053.8	.1246	.0326	.0228	.0098	1470.0
9637	Craigie's Bridge,	Distinct.	Cons.	0.01	Distinct, musty.	Distinct, musty.	-	.0188	.0096	.0088	.0008	1813.0

No. 9634 was collected on November 5, all others on November 7. No. 9639 was examined on the day after collection, all others on the day during which they were collected.

CHARLES RIVER.

Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during Low Water of Spring Tides, Nov. 7, 1892.

[Parts per 100,000.]

Number.	LOCALITY.	Appearance. Turbidity.	Sediment.	Color.	Odor. Cold.	Hot.	Residue on Evaporation.	Ammonia. Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.	Chlorine.
9644	North Beacon St.,	-	-	-	-	-	-	-	-	-	-	47.7
9643	Western Ave., .	Decided.	Heavy, brown.	0.30	Decided, off'nsive	Decided, off'nsive.	1203.8	.1060	.1004	.0340	.0664	586.5
9645	Craigie's Bridge,	Distinct.	Cons.	0.03	Decided, musty.	Distinct, musty.	-	.0808	.0264	.0172	.0092	1635.0

The samples were examined on the day after collection.

Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during High Water of Neap Tides, Nov. 25, 1892.

[Parts per 100,000.]

Number.	LOCALITY.	Appearance. Turbidity.	Sediment.	Color.	Odor. Cold.	Hot.	Residue on Evaporation.	Ammonia. Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.	Chlorine.
9721	Beechwood Ave.,	Distinct, milky.	Slight, earthy.	1.20	Faint, musty.	Decided, musty.	8.0	.0752	.0856	.0656	.0200	1.0
9720	No. Beacon St., .	Distinct, milky.	Slight, earthy.	1.20	Faint, musty.	Distinct, musty.	122.0	.0400	.1124	.0964	.0160	58.0
9718	Western Ave., .	Distinct, milky.	Slight, earthy.	0.95	Distinct.	Decided, musty.	570.0	.0608	.1060	.0912	.0148	280.0
9719	No. Harvard St.,	Slight, milky.	Cons., earthy.	0.40	Distinct.	Distinct, musty.	2040.0	.0832	.0604	.0332	.0272	1030.0
9717	Cambridge St., .	Distinct, milky.	Slight, earthy.	0.30	Faint, musty.	Decided, musty.	2421.0	.0784	.0396	.0284	.0112	1175.0
9716	Essex St., . .	Distinct, milky.	Slight, earthy.	0.25	Faint, musty.	Decided, musty.	2613.0	.0832	.0364	.0304	.0060	1292.0
9709	Harvard Bridge,	Distinct, milky.	Slight, earthy.	0.10	Distinct, musty.	Distinct, musty	2779.0	.0768	.0328	.0308	.0020	1380.0
9725	W. Boston Br.,	Slight.	Slight, earthy.	0.05	Faint, musty.	Distinct, musty.	3130.0	.0720	.0204	.0188	.0016	1539.0
9723	Craigie's Bridge,	V. slight.	Slight, earthy.	0.04	Faint, musty.	Faint, musty.	3308.0	.0816	.0152	.0124	.0028	1658.0
9727	Charles Riv. Br.,	V. slight.	Slight, earthy.	0.05	V. faint, musty.	Faint, musty.	3358.0	.0144	.0188	.0136	.0052	1653.0

The samples were examined on the day after collection.

The free ammonia in these samples was determined a second time after the samples had been standing in the laboratory for a week, with the following results: No. 9721, .0784; No. 9720, .1600; No. 9718, .1920; No. 9719, .1280; No. 9717, .0992; No. 9716, .0960; No. 9709, .1040; No. 9725, .0768; No. 9723, .0400; No. 9727, .0384.

CHARLES RIVER.

Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during Low Water of Neap Tides, Nov. 25, 1892.

[Parts per 100,000.]

Number.	LOCALITY.	Appearance.			Odor.		Residue on Evaporation.	Ammonia.				Chlorine.
									Albuminoid.			
		Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Total.	Dis-solved.	Sus-pended.	
9715	Beechwood Ave.,	Decided, milky.	Heavy.	1.20	Distinct, musty.	Distinct, musty.	7.9	.0160	.0468	.0344	.0124	1.0
9714	No. Beacon St.,	Decided, milky.	Heavy, dirty.	1.20	Faint, musty.	Decided, musty.	9.0	.0176	.0772	.0312	.0460	1.2
9713	Western Ave., .	Decided, milky.	Heavy, dirty.	1.00	Distinct.	Decided, musty.	53.6	.0384	.1740	.1132	.0608	23.8
9712	No. Harvard St.,	Distinct, milky.	Cons., earthy.	0.90	Distinct.	Decided, musty.	535.0	.0480	.0772	.0652	.0120	269.0
9711	Cambridge St., .	Distinct, milky.	Cons., earthy.	0.90	Distinct, musty.	Decided, musty.	862.0	.0592	.0800	.0672	.0128	440.0
9710	Essex St., . .	Distinct, milky.	Cons., earthy.	0.70	Distinct, musty.	Distinct, musty.	1356.0	.0768	.0628	.0568	.0060	680.0
9708	Harvard Bridge,	Distinct, milky.	Cons., earthy.	0.40	Distinct, musty.	Distinct, musty.	1956.0	.0800	.0444	.0388	.0056	1000.0
9724	W. Boston Br.,	Distinct, milky.	Slight, earthy.	0.20	Decided, musty.	Decided, musty.	2500.0	.0608	.0340	.0248	.0092	1255.0
9722	Craigie's Bridge,	Distinct, milky.	Slight, earthy.	0.10	Decided, musty.	Distinct, musty.	2692.0	.0400	.0276	.0244	.0032	1350.0
9726	Charles Riv. Br.,	Slight.	Slight, earthy.	0.10	V. faint, musty.	Distinct, musty.	2934.0	.0400	.0260	.0212	.0048	1473.0

The samples were examined on the day after collection.

The free ammonia in these samples was determined a second time after the samples had been standing in the laboratory for a week, with the following results: No. 9715, .0192; No. 9714, .0208; No. 9713, .1920; No. 9712, .1120; No. 9711, .1280; No. 9710, .1040; No. 9708, .1120; No. 9724, .0992; No. 9722, .0800; No. 9726, .0832.

Deerfield River.

Chemical Examination of Water from the Deerfield River above and below Shelburne Falls.

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
									Albuminoid.						
	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1892.														
9827	Dec. 21	Dec. 22	Slight.	Slight, sandy.	0.08	3.80	0.80	.0002	.0062	.0048	.0014	.14	.0200	.0000	1.9
9828	Dec. 21	Dec. 22	Slight.	Slight, sandy.	0.10	3.70	0.90	.0004	.0136	.0104	.0032	.17	.0180	.0000	1.7

Odor, none; on heating, a very faintly vegetable odor was developed in the last sample. —— The first sample was collected from the river above the village of Shelburne Falls; the last sample, from the river below the village and below all mills.

Microscopical Examination.

No. 9827. Diatomaceæ, *Diatoma*, 2; *Tabellaria*, 2. Fungi, *Molds*, 1. Miscellaneous, *Zoöglœa*, 62. Total, 67.

No. 9828. Algæ, *Conferva*, 1; *Zoöspores*, 1. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 36. Total, 39.

IPSWICH RIVER.

Ipswich River.

During the year 1892, chemical and microscopical examinations of the Ipswich River were made at monthly intervals at three points, viz.: opposite the pumping station of the Reading Water Works, at Mill Street, Reading; at the Salem and Lawrence railroad bridge, near Howe's station, between Danvers and Middleton; and near the eastern division of the Boston & Maine Railroad, just above Ipswich.

The area of the watershed, population, and population per square mile at each of these points, is given in the following table: —

LOCALITY.	Distance above Tide-water. — Miles.	Drainage Area. — Square Miles.	Population. — 1890.	Population per Square Mile.
At pumping station, Reading,	26	19.6	1,331	68
At railroad bridge near Howe's station,	16	52.2	3,564	68
Just above Ipswich,	2	146.1	8,277	57

Chemical Examination of Water from the Ipswich River at Reading, opposite the Pumping Station of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Exam-ination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8468	Jan. 29	Feb. 2	V.slight.	Slight.	1.45	5.95	2.25	.0008	.0276	.0228	.0048	0.46	.0180	.0000	1.7
8513	Feb. 15	Feb. 16	V.slight.	V.slight.	1.20	6.05	2.25	.0014	.0238	.0220	.0018	0.55	.0300	.0000	1.6
8626	Mar. 15	Mar. 17	V.slight.	V.slight.	1.30	4.60	1.85	.0000	.0184	.0170	.0014	0.41	.0070	.0001	0.9
8753	Apr. 18	Apr. 19	V.slight.	V.slight.	1.60	4.50	2.00	.0004	.0312	.0230	.0082	0.36	.0050	.0000	0.6
8899	May 16	May 17	V.slight.	Slight.	1.80	5.70	3.00	.0004	.0312	.0252	.0060	0.41	.0170	.0000	0.9
8995	June 13	June 14	Slight.	Cons., rusty.	1.70	6.25	2.70	.0018	.0286	.0258	.0028	0.44	.0000	.0000	1.5
9124	July 18	July 20	V.slight.	V.slight.	1.60	7.35	2.80	.0006	.0214	.0196	.0018	1.14	.0090	.0001	0.9
9248	Aug 15	Aug. 16	None.	V.slight.	0.85	6.50	2.45	.0000	.0158	.0138	.0020	1.02	.0030	.0001	2.5
9393	Sept. 19	Sept. 20	V.slight.	Slight.	1.70	7.75	3.90	.0000	.0330	.0290	.0040	0.49	.0030	.0002	1.5
9539	Oct. 17	Oct. 18	V.slight.	V.slight.	0.75	5.45	0.60	.0000	.0180	.0134	.0046	0.51	.0090	.0000	2.1
9669	Nov. 14	Nov. 15	Slight.	Slight.	1.20	5.85	2.30	.0000	.0218	.0178	.0040	0.47	.0120	.0000	1.8
9785	Dec. 12	Dec. 13	None.	V.slight.	1.80	6.70	3.05	.0000	.0250	.0206	.0044	0.50	.0150	.0000	1.8
Av.	....	....	....	....	1.41	6.05	2.43	.0004	.0246	.0208	.0038	0.56	.0107	.0000	1.5

Odor, distinctly vegetable and sweetish. —— The samples were collected from the river just below Mill Street. The river above this point receives the liquid wastes from a tannery located in Wilmington, which probably accounts for the high chlorine found in the water at times in the dryer portions of the year.

IPSWICH RIVER.

Microscopical Examination of Water from the Ipswich River at Reading, opposite the Pumping Station of the Reading Water Works.

[Number of organisms per cubic centimeter.]

	1892.											
	Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	18	19	20	17	15	20	16	21	18	15	14
Number of sample,	8468	8513	8626	8753	8899	8995	9124	9248	9393	9539	9669	9785
PLANTS.												
Diatomaceæ,	**4**	**0**	**5**	**5**	**16**	**3**	**pr.**	**3**	**3**	**6**	**0**	**3**
Diatoma,	0	0	0	2	4	0	pr.	pr.	0	0	0	0
Melosira,	1	0	0	2	2	0	0	0	0	0	0	3
Navicula,	0	0	5	0	0	pr.	pr.	2	2	0	0	0
Synedra,	3	0	0	1	10	3	0	1	1	6	0	0
Fungi. Crenothrix,	**4**	**15**	**1**	**78**	**30**	**16**	**14**	**6**	**5**	**5**	**0**	**pr.**
ANIMALS.												
Infusoria,	**36**	**0**	**1**	**19**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**5**
Dinobryon,	29	0	pr.	2	0	0	0	0	0	0	0	5
Dinobryon cases,	7	0	1	15	0	0	0	0	0	0	0	0
Peridinium,	0	0	0	2	pr.	0	0	0	2	0	0	pr.
Miscellaneous. Zoöglœa,	**13**	**1**	**9**	**pr.**	**3**	**38**	**1**	**2**	**0**	**0**	**49**	**0**
TOTAL,	57	16	16	102	49	57	15	11	10	11	49	8

Chemical Examination of Water from the Ipswich River, near Howe's Station, between Danvers and Middleton.

[Parts per 100,000.]

Number.	Date of		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
	1892.														
8459	Jan. 27	Jan. 29	V. slight.	Slight.	1.20	6.55	3.10	.0000	.0194	.0180	.0014	.49	.0100	.0001	1.6
8521	Feb. 16	Feb. 18	V. slight.	Slight.	1.00	6.35	2.35	.0006	.0204	.0180	.0024	.51	.0120	.0001	1.7
8614	Mar. 15	Mar. 16	V. slight.	V. slight.	1.20	5.90	2.00	.0000	.0226	.0176	.0050	.38	.0070	.0000	1.1
8780	Apr. 19	Apr. 21	V. slight.	V. slight.	1.10	4.50	2.20	.0000	.0248	.0236	.0012	.39	.0070	.0000	1.3
8903	May 16	May 18	Slight.	Slight.	1.30	4.85	1.85	.0028	.0370	.0342	.0028	.34	.0100	.0000	1.3
9002	June 14	June 15	Slight.	Slight.	1.60	6.20	2.55	.0006	.0278	.0252	.0026	.43	.0000	.0000	1.3
9129	July 19	July 20	V. slight.	V. slight.	1.70	5.90	3.10	.0006	.0334	.0282	.0042	.40	.0000	.0000	1.6
9262	Aug. 16	Aug. 18	V. slight.	V. slight.	0.55	4.75	1.55	.0022	.0190	.0162	.0028	.67	.0090	.0000	2.0
9413	Sept. 20	Sept. 21	V. slight.	Slight.	1.40	7.55	2.95	.0006	.0370	.0290	.0080	.58	.0100	.0000	1.9
9551	Oct. 20	Oct. 22	V. slight.	Slight.	0.90	6.75	2.50	.0006	.0262	.0230	.0032	.57	.0090	.0001	2.1
9673	Nov. 15	Nov. 16	V. slight	V. slight.	2.50	8.10	4.65	.0000	.0440	.0370	.0070	.48	.0070	.0001	2.6
9790	Dec. 13	Dec. 14	V. slight.	V. slight.	1.90	7.05	3.50	.0012	.0326	.0290	.0036	.43	.0180	.0001	2.5
Av.	....	....	....	....	1.36	6.20	2.69	.0008	.0287	.0250	.0037	.47	.0082	.0000	1.7

Odor, vegetable and grassy or sweetish, rarely mouldy. —— The samples were collected from the river, at the bridge, near Howe's station.

IPSWICH RIVER.

Microscopical Examination of Water from the Ipswich River, near Howe's Station, between Danvers and Middleton.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	18	17	23	19	16	21	18	23	24	16	15
Number of sample,	8459	8521	8614	8780	8903	9002	9129	9262	9413	9551	9673	9790
PLANTS.												
Diatomaceæ,	7	10	45	19	6	3	8	3	7	10	1	14
Asterionella,	0	2	1	2	2	0	pr.	0	0	8	0	2
Diatoma,	pr.	2	1	pr.	0	0	2	0	0	0	0	0
Fragilaria,	0	0	3	1	0	0	2	0	0	0	0	0
Grammatophora,	0	1	0	0	2	0	1	0	4	0	0	0
Synedra,	7	1	38	15	2	0	2	3	2	1	1	8
Tabellaria,	0	4	2	1	0	3	1	0	1	1	0	4
Algæ,	0	pr.	0	0	0	12	0	2	0	0	0	0
Chlorococcus,	0	pr.	0	0	0	4	0	2	0	0	0	0
Raphidium,	0	0	0	0	0	8	0	0	0	0	0	0
Fungi. Crenothrix,	pr.	7	0	3	124	288	72	126	264	120	45	pr.
ANIMALS.												
Infusoria,	27	1	15	1	pr.	4	1	0	0	0	0	17
Dinobryon,	27	0	13	0	0	0	0	0	0	0	0	16
Dinobryon cases,	0	1	2	1	0	4	0	0	0	0	0	0
Peridinium,	pr.	0	0	pr.	0	0	1	0	0	0	0	0
Synura,	0	0	0	0	0	0	0	0	0	0	0	1
Trachelomonas,	0	0	0	pr.	pr.	0	pr.	0	0	0	0	0
Miscellaneous. Zoöglœa,	8	124	3	2	2	1	13	20	0	104	58	28
TOTAL,	42	142	63	25	132	308	94	151	271	234	104	59

IPSWICH RIVER.

Chemical Examination of Water from the Ipswich River, above Ipswich.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8460	Jan. 28	Jan. 29	V.slight.	V.slight.	1.00	6.80	2.70	.0000	.0224	.0196	.0028	.58	.0100	.0002	1.4
8526	Feb. 17	Feb. 18	V.slight.	V.slight.	0.95	6.05	2.10	.0016	.0220	.0210	.0010	.56	.0150	.0001	1.9
8637	Mar. 17	Mar. 18	V.slight.	V.slight.	0.90	5.05	2.60	.0000	.0204	.0196	.0008	.53	.0050	.0000	1.4
8760	April 19	April 20	V slight.	V.slight.	1.00	4.50	2.50	.0004	.0282	.0254	.0028	.42	.0030	.0000	1.7
8892	May 13	May 14	V.slight	Slight	1.20	5.45	2.50	.0000	.0294	.0262	.0032	.42	.0070	.0000	1.7
9014	June 15	June 16	V.slight.	V.slight.	1.20	6.50	3.00	.0016	.0272	.0200	.0072	.44	.0070	.0001	2.1
9130	July 20	July 20	V.slight.	V.slight.	0.90	5.20	2.35	.0004	.0284	.0246	.0038	.35	.0000	.0000	1.9
9261	Aug. 17	Aug. 18	V.slight.	V.slight.	0.35	5.85	1.75	.0004	.0174	.0152	.0022	.64	.0090	.0000	2.5
9414	Sept. 21	Sept. 21	V.slight.	V.slight.	0.50	6.50	1.75	.0004	.0168	.0096	.0072	.67	.0070	.0002	2.3
9544	Oct. 19	Oct. 20	V.slight.	Slight.	0.50	6.30	1.85	.0000	.0196	.0172	.0024	.66	.0000	.0000	2.6
9689	Nov. 17	Nov. 19	Slight.	Slight.	1.30	7.15	3.05	.0004	.0296	.0262	.0034	.54	.0200	.0000	2.2
9793	Dec. 14	Dec. 15	Slight.	Slight.	0.70	5.20	1.90	.0004	.0248	.0196	.0052	.69	.0200	.0002	2.3
Av.	....	....	....	....	0.87	5.88	2.34	.0005	.0238	.0203	.0035	.54	.0086	.0001	2.0

Odor, distinctly vegetable and sweetish, rarely mouldy.—— The samples were collected from the river, about one thousand feet above the upper dam at Ipswich.

Microscopical Examination of Water from the Ipswich River, above Ipswich.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	19	19	20	14	16	21	18	23	20	18	15
Number of sample,	8460	8526	8637	8760	8892	9014	9130	9261	9414	9544	9689	9793
PLANTS.												
Diatomaceæ,	11	13	90	2	9	0	pr.	4	3	2	10	25
Diatoma,	1	1	0	0	0	0	0	0	2	0	0	21
Synedra,	10	12	90	2	5	0	pr.	4	1	2	4	4
Tabellaria,	0	0	pr.	0	4	0	pr.	pr.	0	0	6	0
Fungi. Crenothrix,	6	7	0	2	42	40	142	68	80	204	60	33
ANIMALS.												
Infusoria,	4	3	1	pr.	0	1	pr.	pr.	1	0	9	1
Dinobryon,	4	2	1	0	0	0	0	0	0	0	9	0
Dinobryon cases,	0	1	0	0	0	1	0	0	0	0	0	0
Peridinium,	pr.	0	0	pr.	0	0	0	pr.	0	0	0	pr.
Trachelomonas,	0	0	0	0	0	0	pr.	0	1	0	0	1
Miscellaneous. Zoöglœa,	5	6	0	4	10	0	5	66	0	42	43	3
TOTAL,	26	29	91	8	61	41	147	138	84	248	122	62

Merrimack River.

Regular monthly examinations of the water of the Merrimack River have been made during the year at points opposite the intakes of the Lawrence and Lowell water works, the detailed results of which will be found on pages 149 and 157 of this volume. A comparison of the analyses made at these two places is contained in the following table: —

Table comparing the Analyses above Lowell with those above Lawrence, 1892.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Number of determinations compared,	11	11	11	11	11	11	11	11	11	11	11
Mean of analyses above Lowell,	0.37	3.64	1.35	.0023	.0144	.0115	.0029	.146	.0092	.0001	1.4
Mean of analyses above Lawrence,	0.43	4.12	1.47	.0042	.0181	.0152	.0029	.185	.0105	.0001	1.4
Increase,	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013	.0000	0.0

In order to compare these results with similar ones obtained in previous years, another table is presented, which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years: —

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887-1889,	0.01	0.23	0.09	.0007	.0027	.0017	.0009	.026	.0003*	.0000	–
Increase, 1890,	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891,	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892,	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013	.0000	0.0

The average flow of the river at Lawrence, per twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931 and 5,433 cubic feet per second.

* Decrease.

Nashua River.

During the dryer portions of the year 1892 occasional examinations were made of those portions of the north and south branches of the Nashua River, lying below Fitchburg and Clinton, with a view to determining the extent to which these portions of the river were polluted. Regular monthly examinations have also been made throughout the year of the Stillwater and Quinepoxet rivers, which unite at West Boylston to form the South Branch of the Nashua River. Both streams drain a hilly country, containing a small population mostly engaged in farming. The fall of the streams is quite rapid, and is utilized by a number of manufacturing establishments. The areas drained by these rivers at their confluence are, respectively: Quinepoxet, 54.8 square miles; Stillwater, 40.5 square miles.

Chemical Examination of Water from the North Branch of the Nashua River, below Fitchburg.

[Parts per 100,000.]

Number.	Appearance.			Residue on Evaporation.				Ammonia.				Chlorine.	Nitrogen as		Hardness.
				Total.		Loss on Ignition.			Albuminoid.						
	Turbidity.	Sediment.	Color.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
9613	Decided.	Heavy, gray.	*0.60	18.80	17.70	4.80	4.20	.0992	.0664	.0520	.0144	1.53	.0100	.0014	3.8
9614	Decided	Cons., gray.	*0.50	17.50	15.50	4.30	3.10	.0992	.0688	.0476	.0212	1.55	.0100	.0011	3.9

Odor, offensive. —— The samples were collected Nov. 1, 1892, from the canal above the mill of the Falulah Paper Company, at the Sheridan Street Bridge. The first sample was collected at 1.15 P.M. and the second at 6.15 P.M.

* These figures are only approximate, as the water was too turbid to determine the amount of color definitely.

NASHUA RIVER.

Chemical Examination of Water from the North Branch of the Nashua River, just above its Confluence with the South Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9277	Aug. 18	Aug. 19	Slight.	Cons.	0.50	7.30	2.25	.0032	.0260	.0222	.0038	.74	.0350	.0012	2.7
9568	Oct. 25	Oct. 26	Slight.	Slight, white.	0.50	10.80	1.90	.0394	.0292	.0268	.0024	1.27	.0500	.0004	3.2
9607	Nov. 1	Nov. 2	Slight.	Slight.	0.45	11.15	2.15	.0840	.0268	.0220	.0048	1.33	.0500	.0015	3.1
Av.	....	....	....	....	0.48	9.75	2.10	.0422	.0274	.0237	.0037	1.11	.0450	.0010	3.0

Odor, musty; much stronger in the last two samples than in the first. —— The samples were collected from the river at the railroad bridge, a short distance above its mouth.

Microscopical Examination.

No. 9277. Diatomaceæ, *Cymbella*, 1; *Diatoma*, 1; *Melosira*, 2; *Navicula*, 1; *Synedra*, 6. Algæ, *Chlorococcus*, 10; *Pandorina*, 1; *Pediastrum*, 1; *Scenedesmus*, 2; *Selenastrum*, 2; *Sorastrum*, 1. Fungi, *Crenothrix*, 3; *Molds*, 1. Infusoria, *Peridinium*, 1; *Rhipidodendron*, 2. Miscellaneous, *Zoöglœa*, 236. Total, 271.

No. 9568. Diatomaceæ, *Fragilaria*, 4; *Navicula*, 48; *Synedra*, 8. Algæ, *Closterium*, 1; *Euastrum*, 1; *Scenedesmus*, 1; *Zoöspores*, 1. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 60. Total, 127.

(No. 9607. Not examined.)

Chemical Examination of Water from the South Branch of the Nashua River, just above its Confluence with the North Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
9276	Aug. 18	Aug. 19	Slight.	Cons., rusty.	0.50	4.75	1.65	.0200	.0280	.0202	.0078	.36	.0050	.0008	1.7
9569	Oct. 25	Oct. 26	Distinct.	Cons., shreds.	0.30	5.65	1.50	.0086	.0244	.0204	.0040	.60	.0250	.0001	1.9
9606	Nov. 1	Nov. 2	Distinct.	Cons., gray.	0.50	6.65	1.80	.0256	.0276	.0236	.0040	.82	.0150	.0010	1.7
Av.	....	....	....	....	0.43	5.68	1.65	.0181	.0267	.0214	.0053	.59	.0150	.0006	1.8

Odor, musty; much stronger in the last sample than in the other two. —— The samples were collected from the river at the Atherton bridge, a short distance above its mouth.

Microscopical Examination.

No. 9276. Diatomaceæ, *Diatoma*, 12; *Epithemia*, 1; *Grammatophora*, 2; *Melosira*, 10; *Navicula*, 5; *Synedra*, 4; *Tabellaria*, 2. Algæ, *Chlorococcus*, 1; *Cosmarium*, 1; *Nephrocytium*, 2; *Pediastrum*, 1; *Scenedesmus*, 10; *Zoöspores*, 2. Fungi, *Crenothrix*, 74. Infusoria, *Dinobryon cases*, 5; *Peridinium*, 1; *Trachelomonas*, 3. Crustacea, *Cyclops*, .01. *Miscellaneous*, Zoöglœa, 336. Total, 472.

No. 9569. Diatomaceæ, *Grammatophora*, 1; *Melosira*, 5; *Navicula*, 4; *Synedra*, 1. Algæ, *Chlorococcus*, 2; *Scenedesmus*, 2; *Zoöspores*, 1. Fungi, *Crenothrix*, 196. Infusoria, *Dinobryon cases*, 3; *Monas*, 1; *Peridinium cases*, 1; *Trachelocerca*, 7; *Trachelomonas*, 1. Vermes, *Rotifer*, 2. Miscellaneous, *Zoöglœa*, 256. Total, 477.

(No. 9606. Not examined.)

NASHUA RIVER.

Chemical Examination of Water from the Quinepoxet River in Holden.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8458	Jan. 28	Jan. 29	Slight.	Slight.	0.60	3.65	1.25	.0002	.0098	.0090	.0008	.18	.0120	.0000	0.5
8544	Feb. 20	Feb. 23	Slight.	Cons., gray.	0.40	3.40	0.75	.0000	.0130	.0104	.0026	.20	.0150	.0001	0.8
8673	Mar. 26	Mar. 28	Slight.	Slight.	0.45	2.65	0.95	.0000	.0130	.0098	.0032	.12	.0100	.0000	0.3
8761	Apr. 19	Apr. 20	Slight.	Cons.	0.40	2.55	1.30	.0000	.0180	.0132	.0048	.19	.0050	.0001	0.9
8907	May 17	May 18	V. slight.	Cons.	0.70	3.25	1.70	.0000	.0218	.0192	.0026	.12	.0030	.0000	0.5
9003	June 15	June 16	Slight.	Cons., earthy.	0.55	4.20	1.50	.0016	.0244	.0188	.0056	.14	.0050	.0001	0.8
9110	July 15	July 15	V. slight.	Cons.	0.50	4.00	1.55	.0022	.0212	.0176	.0036	.24	.0050	.0000	1.3
9256	Aug. 16	Aug. 17	Slight.	Cons.	0.80	4.35	2.30	.0072	.0260	.0234	.0026	.26	.0150	.0001	1.9
9395	Sept. 19	Sept. 20	V. slight.	Slight.	0.60	3.85	1.60	.0004	.0214	.0184	.0030	.18	.0070	.0002	0.3
9549	Oct. 21	Oct. 22	Slight.	Slight.	0.55	4.00	1.45	.0052	.0212	.0152	.0060	.25	.0100	.0001	1.1
9701	Nov. 22	Nov. 22	V. slight.	Slight.	1.20	4.65	1.85	.0004	.0236	.0206	.0030	.21	.0070	.0001	1.4
9809	Dec. 17	Dec. 19	Slight.	V. slight.	0.70	3.90	1.70	.0000	.0192	.0142	.0050	.24	.0120	.0000	0.9
Av.	....	....	....	....	0.62	3.70	1.49	.0014	.0194	.0158	.0036	.19	.0088	.0001	0.9

Odor, faintly vegetable, frequently mouldy, very seldom none; on heating, the odor becomes stronger and generally mouldy. —— The samples were collected from the river at Smith's woolen mill in Holden, about one thousand feet from the line between Holden and West Boylston.

Microscopical Examination of Water from the Quinepoxet River in Holden.

[Number of organisms per cubic centimeter.]

	1892. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	24	29	21	19	16	16	17	21	22	23	20
Number of sample,	8458	8544	8673	8761	8907	9003	9110	9256	9395	9549	9701	9809
PLANTS.												
Diatomaceæ,	**3**	**4**	**5**	**140**	**259**	**94**	**61**	**111**	**14**	**15**	**51**	**35**
Asterionella,	2	pr.	0	9	64	0	1	28	0	pr.	4	1
Cyclotella,	0	0	0	7	pr.	pr.	pr.	2	0	0	0	pr.
Diatoma,	0	pr.	3	0	54	7	24	2	1	1	1	0
Fragilaria,	0	0	0	0	0	0	0	8	4	2	0	0
Melosira,	0	2	2	5	4	4	11	62	7	0	45	0
Navicula,	0	0	pr.	3	1	pr.	3	2	pr.	pr.	0	0
Synedra,	1	2	pr.	116	136	80	20	7	1	12	1	34
Tabellaria,	0	0	0	0	0	3	2	0	1	pr.	0	0

NASHUA RIVER.

Microscopical Examination of Water from the Quinepoxet River in Holden — Concluded.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	**0**	**0**	**0**	**pr.**	**5**	**19**	**10**	**15**	**1**	**1**	**0**	**0**
Chlorococcus,	0	0	0	0	4	11	6	2	0	pr.	0	0
Hyalotheca,	0	0	0	0	0	6	0	0	0	0	0	0
Protococcus,	0	0	0	0	0	1	0	9	0	0	0	0
Scenedesmus,	0	0	0	pr.	1	1	4	4	1	1	0	0
Fungi,	**0**	**0**	**pr.**	**1**	**5**	**13**	**13**	**pr.**	**59**	**12**	**0**	**7**
Crenothrix,	0	0	0	1	5	13	13	pr.	58	12	0	0
Molds,	0	0	pr.	0	0	0	0	0	1	0	0	7
ANIMALS.												
Infusoria,	**1**	**pr.**	**11**	**pr.**	**8**	**1**	**pr.**	**1**	**pr.**	**7**	**1**	**3**
Dinobryon,	1	0	0	0	0	0	0	0	0	4	0	1
Dinobryon cases,	0	0	0	0	7	0	0	0	0	1	0	0
Peridinium,	pr.	pr.	11	pr.	1	pr.	pr.	0	pr.	2	1	2
Trachelomonas,	0	0	0	0	pr.	1	pr.	1	pr.	pr.	0	pr.
Miscellaneous. Zoöglœa,	**33**	**420**	**82**	**326**	**120**	**162**	**242**	**68**	**52**	**50**	**32**	**410**
TOTAL,	37	424	98	467	397	289	326	195	126	85	84	455

Chemical Examination of Water from the Stillwater River in Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
	1892.														
8455	Jan. 28	Jan. 29	None.	V. slight.	0.50	3.10	1.15	.0000	.0066	.0062	.0004	.16	.0090	.0000	0.6
8543	Feb. 20	Feb. 23	V. slight.	Slight.	0.30	3.35	0.75	.0000	.0104	.0090	.0014	.16	.0100	.0000	0.9
8672	Mar. 26	Mar. 28	None.	V. slight.	0.35	2.75	0.80	.0000	.0118	.0088	.0030	.10	.0150	.0000	0.8
8762	Apr. 19	Apr. 20	V. slight.	Cons., earthy.	0.30	3.35	1.35	.0010	.0122	.0110	.0012	.13	.0050	.0000	0.6
8908	May 17	May 18	V. slight.	Slight.	0.75	3.55	1.40	.0000	.0202	.0146	.0056	.08	.0020	.0000	0.6
9024	June 20	June 21	V. slight.	Slight.	0.40	3.60	1.50	.0002	.0164	.0122	.0042	.16	.0050	.0000	1.3
9111	July 15	July 15	V. slight.	Slight.	0.35	3.70	1.30	.0000	.0126	.0124	.0002	.09	.0050	.0000	1.3
9257	Aug. 16	Aug. 17	V. slight.	Slight.	0.35	3.20	1.00	.0002	.0152	.0130	.0022	.11	.0100	.0000	0.8
9396	Sept. 19	Sept. 20	V. slight	Slight.	0.35	3.45	1.20	.0000	.0118	.0102	.0016	.04	.0030	.0003	0.5
9550	Oct. 21	Oct. 22	Slight.	Slight.	0.25	3.40	1.00	.0002	.0150	.0122	.0028	.15	.0100	.0000	1.1
9702	Nov. 22	Nov. 22	V. slight.	V. slight.	0.90	3.85	1.45	.0000	.0152	.0132	.0020	.15	.0050	.0001	1.3
9810	Dec. 17	Dec. 19	None.	V. slight.	0.45	3.30	1.25	.0000	.0098	.0086	.0012	.16	.0070	.0000	0.8
Av.	....	....	....	....	0.44	3.38	1.18	.0001	.0131	.0109	.0022	.13	.0072	.0000	0.9

Odor, vegetable, and frequently also mouldy, sometimes none. —— The samples were collected from the river at a road bridge just below the outlet of a mill-pond, and about one mile above the line between Sterling and West Boylston.

NASHUA RIVER.

Microscopical Examination of Water from the Stillwater River in Sterling.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	30	24	29	21	19	22	16	17	21	22	22	20
Number of sample,	8455	8543	8672	8762	8908	9024	9111	9257	9396	9550	9702	9810
PLANTS.												
Diatomaceæ,	pr.	8	5	53	459	19	6	24	10	19	0	1
Asterionella,	0	3	1	2	0	0	1	0	0	0	0	0
Diatoma,	0	0	0	8	4	7	pr.	2	7	pr.	0	0
Fragilaria,	0	0	0	6	13	0	0	5	0	9	0	0
Melosira,	0	0	3	0	2	0	1	8	3	5	0	0
Meridion,	0	0	1	4	0	0	0	1	0	0	0	0
Navicula,	0	0	0	2	pr.	1	2	6	pr.	1	0	0
Synedra,	pr.	5	pr.	31	440	11	2	2	pr.	4	0	1
Fungi. Crenothrix,	pr.	2	pr.	pr.	2	0	18	5	7	26	0	0
ANIMALS.												
Infusoria,	pr.	0	0	1	0	0	2	pr.	0	6	0	0
Dinobryon,	0	0	0	0	0	0	0	0	0	5	0	0
Peridinium,	pr.	0	0	1	0	0	2	pr.	0	1	0	0
Miscellaneous. Zoöglœa,	1	17	34	3	0	58	8	28	6	76	25	9
TOTAL,	1	27	39	57	461	77	34	57	23	127	25	10

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

At the end of 1892 the State contained 28 cities* and 324 towns, the only change during the year being the addition of one town by the division of the town of Tisbury, a portion of which was set off under the name of West Tisbury, April 28, 1892.

The year has been an active one in water works construction, as several of the larger places have been at work on the construction of additional water supplies, and other towns which had only a limited water supply have new works far advanced toward completion. Manchester, however, is the only place which during the year introduced a public water supply for the first time, and with this addition all the cities and 115 towns in the State, a total of 143 places, are provided with a public water supply.

The following table gives a classification, by population, of cities and towns having and not having public water supplies Dec. 31, 1892. The populations are taken from the census of 1890 : —

Population (1890).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	28	9,772
500-1,000,	5	4,566	63	48,167
1,000-1,500,	5	5,954	44	54,105
1,500-2,000,	8	13,857	27	48,382
2,000-2,500,	9	19,987	14	30,299
2,500-3,000,	7	19,663	18	49,262
3,000-3,500,	8	26,010	5	15,899
3,500-4,000,	6	22,457	3	11,263
4,000-4,500,	11	47,201	5	21,367
4,500-5,000,	13	60,954	1	4,642
Above 5,000,	71	1,718,998	1	6,138
Totals,	143	1,939,647	209	299,296

From the totals given in the table it will be seen that, although but forty per cent. of the cities and towns in the State have a public water supply, yet the total population of places supplied represents

* On Jan. 2, 1893, the towns of Medford and Everett became cities, making 30 in all.

86.6 per cent. of the whole population of the State. In this estimate of the total population of municipalities supplied all of the inhabitants in them are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available; the difference, however, is not large. There are now but 7 towns having, by the census of 1890, a population exceeding 4,000, which are not provided with a public water supply. These are given in the following table: —

Towns.	Population in 1890.	Towns.	Population in 1890.
Blackstone,	6,138	Winchendon,	4,390
Provincetown,*	4,642	Rockport,	4,087
Ipswich,	4,439	Barnstable,	4,023
Millbury,	4,428		

* Works for the supply of Provincetown were begun early in 1893.

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town: —

Years.	Number of Places Supplied.	Years.	Number of Places Supplied.
Previous to 1850,	6	1890,	5
1850-1859, inclusive,	4	1891,	5
1860-1869, inclusive,	10	1892,	1
1870-1879, inclusive,	44		
1880-1889, inclusive,	68	Total,	143

With regard to the ownership of water supplies, the cities of Chicopee and Quincy and the towns of Stoughton and West Springfield purchased the works of the local water companies, and in each of these places the works are now under municipal control.

Of the 28 cities in the Commonwealth, 26, having a total population in 1890 of 1,333,702, own their water works; while 2, having a total population of 38,598, are wholly supplied by private companies. Of the 115 towns having public water supplies, 67, with a total population of 362,295, are supplied from their own works, while 48, with a total population of 205,052, are supplied by private companies. The total population in both cities and towns owning their works is 1,695,997, against 243,650 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in many of the cities and towns in this State. The popu-

lations for 1892, as given in the table, were obtained in a somewhat arbitrary manner by adding two-fifths of the increase in population from 1885 to 1890 to the population as determined by the census taken in the latter year. The daily consumption per *inhabitant*, obtained by dividing the average daily consumption by the total population of the city or town in 1892, is less than the amount per *consumer*, because there are some in all cities and towns who do not use the public water supply. This difference between the number of inhabitants and consumers accounts, to a large extent, for the low rate, per inhabitant, in some towns where works have been in operation only a short time and in consequence water has not been generally introduced; also, in towns where there are villages to which the public water supply has not been extended; but, after making all due allowance for the varying proportion of water takers, there is still a very great difference in the amount of water used per person in different places, which it is very difficult to account for.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Population. 1892.	Average Daily Consumption. Gallons. 1892.	Daily Consumption per Inhabitant. Gallons.
Abington and Rockland,	9,869	298,000	30
Andover,	6,314	234,000	37
Avon,	1,478	41,000	28
Ayer,	2,132	69,000	32
Beverly,	11,475	801,000	70
Boston (Cochituate Works),	433,093	41,312,000	95
Boston, Somerville, Chelsea and Everett (Mystic Works),	124,796	9,811,000	79
Braintree,	5,171	323,000	62
Bridgewater and East Bridgewater,	7,369	125,000	17
Brockton,	29,898	744,000	25
Brookline,	13,266	1,067,000	80
Cambridge,	74,176	5,358,000	72
Canton,	4,601	200,000	44
Cohasset,	2,541	60,000	23
Danvers and Middleton,	8,545	538,000	63
Dedham,	7,316	275,000	38
Easton,	4,711	99,000	21
Fall River,	81,409	2,286,000	28
Foxborough,	2,981	43,000	15
Framingham,	9,625	226,000	24
Franklin,	5,170	99,000	19
Gardner,	8,880	620,000	70
Gloucester,	25,830	551,000	21
Hyde Park and Milton,	15,487	564,000	36
Lawrence,	46,971	3,588,000	77
Lowell,	83,132	6,074,000	73
Lynn * and Saugus,	67,000	3,549,000	53
Manchester,	1,849	67,000	38
Mansfield,	3,629	174,000	48
Marblehead,	8,476	217,000	26
Marlborough,	14,951	425,000	28
Middleborough,	6,426	170,000	26
Montague,	6,563	373,000	57
Nantucket,	3,318	79,000	24
Natick,	9,381	361,000	39
Needham,	3,215	65,000	20
New Bedford,*	50,000	4,393,090	88
Newburyport,	14,039	506.000	36
Newton,	26,227	1,288,000	49
No. Attleborough,	6,873	176,000	26
Norwood,	4,058	169,000	42
Quincy,	18,554	602,000	32
Randolph and Holbrook,	6,532	258,000	40
Reading,	4,308	165,000	38
Revere and Winthrop,	9,748	543,000	56
Salem,	31,885	2,582,000	81
Sharon,	1,756	27,000	16
Swampscott and Nahant,	4,466	263,000	59
Taunton,	26,158	1,012,000	39
Waltham,	20,346	919,000	45
Ware,	7,859	191,000	24
Wakefield and Stoneham,	13,704	606,000	44
Watertown and Belmont,	9,689	407,000	42
Wellesley,	3,835	239,000	62
Whitman,	4,779	158,000	33
Woburn,	14,199	800,000	56

* The growth of these places has been very rapid since 1890, and the estimates of population given by the superintendents of water works have therefore been used.

Rainfall.

The rainfall for the year 1892 was 4.09 inches below the normal amount, but was so distributed that there was no very severe drought during any portion of the year. The greatest deficiency in rainfall occurred in February, March and April, causing an unusually small flow in the streams during these months; and, as many ponds had been drawn to a very low level at the end of 1891, they failed to fill to high-water mark in the spring, and consequently have been drawn to a still lower level in 1892.

The average annual rainfall * in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.15 inches. In the following table is given the normal rainfall for each month in the year, the rainfall for each month in 1892 and the departures from the normal. †

	Normal Rainfall. Inches.	Rainfall, 1892. Inches.	Excess or Deficiency. Inches.		Normal Rainfall. Inches.	Rainfall, 1892. Inches.	Excess or Deficiency. Inches.
1892.				1892.			
January,	4.03	5.14	+1.11	August,	4.38	5.82	+1.44
February,	3.62	2.32	—1.30	September,	3.35	2.09	—1.26
March,	4.07	3.44	—0.63	October,	3.87	1.51	—2.36
April,	3.31	0.94	—2.37	November,	4.13	5.42	+1.29
May,	3.65	5.90	+2.25	December,	3.50	1.37	—2.13
June,	3.31	3.38	+0.07	Totals,	45.15	41.06	—4.09
July,	3.93	3.73	—0.20				

* Including melted snow.

† This and subsequent tables of rainfall have been prepared from the records of the New England Meteorological Society.

To enable the condition preceding the collection of samples of water in any part of the State to be understood, the following tables are presented, which give the daily rainfall in inches at nine stations scattered about the State: —

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.

January, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.92	1.10	1.38	1.83	*	-	*	1.15	*
3, . .	0.20	0.12	-	-	1.15	0.87	0.76	0.05	0.86
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	0.20	0.36	0.34	0.64	0.50	0.43	0.65	*	0.55
7, . .	0.25	-	-	-	-	-	-	0.80	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.15	0.02	0.17	0.04	-	0.10	-	0.04	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.10	-	0.04	0.03	-	0.06	0.13	0.12	*
12, . .	0.05	0.10	0.08	*	*	-	*	0.42	*
13, . .	2.00	1.33	1.39	*	1.30	-	1.18	0.62	*
14, . .	0.25	0.44	0.16	1.57	*	-	0.16	0.04	*
15, . .	0.70	0.72	0.69	0.68	0.55	1.90	0.60	0.72	1.33
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.20	0.24	0.17	*	0.79	-	*	0.03	-
19, . .	1.30	1.05	0.81	0.81	0.16	-	0.74	1.11	0.98
20, . .	0.25	-	-	0.35	-	1.03	0.35	0.13	0.60
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	0.02	-	-	-
24, . .	-	-	-	-	-	-	-	-	0.01
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	0.02	-	-	-
27, . .	-	-	-	-	-	-	0.03	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	0.05	-	0.05	0.05	-	0.02	0.01	0.01	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	6.62	5.48	5.28	6.00	4.45	4.45	4.61	5.24	4.33

February, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.20	*	0.40	*	*	-	*	*	*
3, . .	0.60	0.59	0.44	0.93	0.96	0.73	0.87	0.86	0.52
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	*	-	-	-	-	-	-	-
7, . .	0.10	0.17	0.09	*	*	-	*	*	*
8, . .	0.10	-	0.16	0.30	0.30	0.05	0.26	0.24	0.32
9, . .	-	-	0.03	0.03	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.50	*	1.35	1.64	*	1.17	*	1.15	1.19
12, . .	-	0.80	-	-	1.35	-	1.36	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	0.10	-	0.15	0.12	*	-	-	*	-
15, . .	0.15	-	-	-	0.07	0.20	0.09	0.15	0.18
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	0.35	*	0.14	0.12	-	-	-	-	-
21, . .	0.05	0.25	0.03	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	0.01
23, . .	-	-	-	*	-	-	-	-	-
24, . .	-	-	0.02	0.04	-	0.03	-	0.06	-
25, . .	-	-	-	0.02	0.10	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
Totals,	2.15	1.81	2.81	3.20	2.78	2.18	2.58	2.46	2.22

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

March, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.20	*	0.27	*	*	-	*	*	*
2, . .	0.10	*	0.27	*	*	-	*	1.00	0.80
3, . .	0.05	0.27	0.81	1.06	1.06	-	0.92	*	*
4, . .	-	-	-	-	-	0.69	0.02	0.03	1.00
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	0.60	0.50	0.47	*	0.70	-	*	*	*
9, . .	0.10	0.03	0.02	0.72	-	0.44	0.60	0.88	0.94
10, . .	-	0.15	0.32	0.30	0.43	0.28	*	*	*
11, . .	0.35	0.35	0.07	-	-	-	0.31	1.17	0.35
12, . .	-	0.08	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	0.05	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.40	*	0.72	*	*	-	*	0.43	*
19, . .	0.20	0.87	-	1.20	1.06	0.72	1.30	0.57	1.57
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.85	*	0.81	0.73	0.70	0.61	0.61	0.73	0.70
24, . .	-	1.04	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	2.85	3.29	3.81	4.01	3.95	2.74	3.76	4.81	5.36

April, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	0.02
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.15	-	-	0.07	-	-	-	0.15	0.21
5, . .	-	0.15	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	0.02	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	0.23	0.09
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	0.40
15, . .	-	-	-	-	-	-	-	0.02	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.30	0.24	0.30	*	*	-	*	0.47	0.69
22, . .	0.15	0.30	0.24	0.50	0.48	0.43	0.43	*	0.44
23, . .	0.15	-	-	0.14	0.21	0.11	0.10	0.22	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	0.05	-	0.03	-	-	0.06	0.03	-	-
29, . .	0.05	-	-	0.12	0.06	-	0.07	0.77	0.44
30, . .	-	-	-	-	-	-	-	-	-
Totals,	0.85	0.69	0.57	0.85	0.75	0.60	0.63	1.86	2.29

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

May, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	0.10	0.15	0.07	0.06	0.07	-	*	*	*
2, . .	0.30	0.32	0.46	*	0.30	0.16	0.09	0.12	0.18
3, . .	0.35	0.34	0.03	*	-	0.40	0.21	0.42	0.14
4, . .	0.55	0.63	0.60	0.73	0.42	0.46	0.78	0.20	0.17
5, . .	-	-	-	-	-	-	-	-	-
6, . .	0.05	0.08	-	-	-	0.01	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.20	0.25	0.36	*	0.60	-	0.65	0.68	*
12, . .	0.05	0.03	0.06	0.48	-	0.51	-	-	0.91
13, . .	0.30	0.26	0.09	0.10	-	0.10	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	1.00	0.97	1.05	*	1.02	-	1.46	*	0.73
16, . .	-	0.03	-	0.94	-	1.25	0.01	1.04	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.10	0.02	0.02	-	*	-	*	*	*
20, . .	0.72	1.05	0.86	-	1.12	-	0.66	1.05	1.05
21, . .	1.10	1.14	1.33	-	1.34	-	*	*	*
22, . .	0.56	0.44	0.43	2.13	*	2.09	1.51	0.45	0.45
23, . .	0.75	0.70	0.85	0.79	0.72	0.68	0.31	0.70	0.32
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	0.03	-	-	0.06	-	-	-
26, . .	0.15	0.10	-	0.19	0.36	-	0.21	0.14	0.15
27, . .	0.45	0.30	0.19	0.15	0.13	0.09	0.21	0.11	0.11
28, . .	-	-	-	-	-	-	-	0.05	0.07
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	0.02	-	0.07	-
31, . .	-	-	-	-	-	-	0.01	-	-
Totals,	6.73	6.81	6.43	5.57	6.08	5.83	6.11	5.03	4.28

June, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.60	0.05	-	*	-	-	-	-	-
3, . .	0.25	-	0.13	0.22	0.27	0.33	0.16	-	0.90
4, . .	-	0.09	0.04	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	0.11	-	0.32	0.20	0.11	0.10	0.32
7, . .	-	-	-	-	-	-	-	0.03	-
8, . .	-	-	-	-	*	-	-	-	-
9, . .	0.30	0.20	0.13	0.33	0.29	0.47	0.37	0.75	0.11
10, . .	-	-	-	-	-	-	-	0.01	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	0.60	0.28	0.29	0.26	0.13	-	-	0.07	0.30
15, . .	-	-	-	-	-	0.29	0.19	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	0.30	-	0.13	0.94	1.18	0.54	1.15	0.33	*
18, . .	0.02	-	-	-	-	-	-	0.55	0.86
19, . .	-	-	-	-	-	-	-	-	0.08
20, . .	0.05	-	-	-	-	-	-	0.01	-
21, . .	-	0.50	-	-	-	-	-	-	*
22, . .	-	-	-	-	-	-	-	-	0.14
23, . .	0.50	0.82	0.17	0.10	-	0.06	0.06	0.32	0.07
24, . .	-	-	0.11	-	-	-	-	-	0.20
25, . .	0.20	0.43	0.31	0.42	0.87	1.12	0.85	-	-
26, . .	-	0.07	0.67	*	0.41	-	-	0.65	-
27, . .	0.15	0.07	0.14	*	-	0.41	0.31	0.02	-
28, . .	0.10	-	0.22	0.44	0.42	0.28	0.37	0.75	0.29
29, . .	-	-	-	-	-	-	-	-	-
30, . .	0.60	0.41	0.33	0.04	-	0.17	-	0.01	0.02
Totals,	3.67	2.92	2.78	2.75	3.89	3.87	3.57	3.60	3.29

* Precipitation included in that of following day.

† Average of rainfall at Plymouth and Providence. No record of rainfall at Taunton for this month.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

July, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.25	0.30	0.06	0.19	0.19	0.15	0.13	0.17	*
2, . .	-	-	-	-	-	-	-	-	0.42
3, . .	1.10	0.70	0.98	0.78	0.88	0.02	0.09	0.14	0.02
4, . .	0.45	0.63	-	-	-	0.81	0.57	0.57	0.56
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	0.03	-	-	-	-	-	0.13
7, . .	-	-	-	-	-	-	-	-	-
8, . .	0.05	-	0.03	-	-	-	-	-	-
9, . .	0.05	0.17	0.30	0.25	0.04	0.04	*	0.02	0.08
10, . .	-	-	-	-	-	-	0.18	0.02	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	0.60	0.17	-	0.08	-	-	-	-	-
14, . .	-	0.13	-	0.88	-	-	-	-	-
15, . .	-	0.44	-	-	-	-	1.07	-	-
16, . .	0.32	-	0.36	0.33	0.16	0.20	0.13	0.16	0.15
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.50	0.67	0.05	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	0.44	-	-	0.02	0.42
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	0.55	1.51	0.17	0.14	-	-	-	-	0.60
29, . .	1.05	1.23	0.16	0.29	0.31	0.02	-	0.03	-
30, . .	-	-	0.08	-	-	-	0.05	-	-
31, . .	1.00	1.20	0.72	1.28	1.33	-	0.81	0.47	0.70
Totals,	5.92	7.15	2.94	4.22	3.35	1.24	3.03	1.60	3.08

August, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	1.05	0.85	0.24	*	0.06	0.43	0.01	0.57	-
2, . .	-	-	-	*	-	-	-	-	-
3, . .	0.90	1.22	0.88	0.30	0.34	0.40	0.37	0.05	0.06
4, . .	0.15	0.30	0.04	-	-	-	0.02	-	-
5, . .	0.06	0.10	0.10	-	0.25	0.18	1.71	0.01	0.24
6, . .	-	0.02	-	-	-	-	0.07	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.25	-	0.03	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.30	-	0.05	*	-	-	-	-	-
12, . .	0.70	1.20	1.73	1.03	2.19	0.87	1.81	0.75	1.69
13, . .	0.32	0.90	0.18	0.19	0.31	0.12	0.03	0.05	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.12	-	-	-	-	-	-	-	-
20, . .	0.05	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	0.02
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	0.35	0.30	0.58	*	*	-	*	-	-
26, . .	1.17	1.53	2.26	1.10	*	-	1.04	0.54	-
27, . .	0.75	0.98	1.66	-	2.46	-	0.94	0.43	1.01
28, . .	-	-	-	1.74	0.05	1.47	0.16	0.04	0.76
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
31, . .	0.05	-	-	0.12	0.26	-	0.65	0.32	0.04
Totals,	6.22	7.40	7.75	4.48	5.92	3.47	6.81	2.76	3.82

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

September, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	*
5, . .	-	-	-	-	-	-	0.10	0.20	0.89
6, . .	0.40	0.32	0.15	0.06	-	0.13	-	0.01	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	1.25	1.18	1.37	2.26	1.62	-	*	1.90	0.46
15, . .	-	0.27	0.09	-	-	2.07	1.04	-	1.22
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	0.07	-	-	-	-	0.08	-	-
20, . .	-	-	-	-	-	-	-	-	0.04
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	0.01	-	-	-	-	0.02	*
24, . .	0.10	0.05	-	0.12	0.12	-	-	-	0.12
25, . .	-	-	-	-	-	-	-	0.15	0.04
26, . .	0.05	0.10	0.13	0.15	0.42	0.17	0.39	0.59	0.77
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
Totals,	1.80	1.99	1.75	2.59	2.16	2.37	1.61	2.87	3.54

October, 1892.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	*	*	-	*	0.01	*
4, . .	0.15	0.11	-	0.12	*	0.07	0.06	0.18	0.18
5, . .	0.20	0.16	-	0.58	1.72	0.47	1.61	0.58	0.75
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.20	-	0.13	0.05	0.07	0.09	0.07	0.14	0.23
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.10	0.37	0.12	*	0.38	0.27	0.43	0.60	0.44
17, . .	-	0.09	0.02	0.39	-	0.07	-	-	0.03
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	0.17	-	0.12	0.27	0.48	-	0.04
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.15	-	0.18	0.14	0.10	0.21	0.13	0.23	0.18
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	0.80	0.73	0.62	1.28	2.39	1.45	2.78	1.74	1.85

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Concluded.

November, 1892. **December, 1892.**

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.	Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	-	-	-	-	-	-	-	0.04	-	1, .	*	0.09	-	0.02	-	0.04	-	-	0.03
2, .	0.20	0.38	0.18	*	*	-	0.09	-	*	2, .	0.10	-	-	-	-	-	-	-	-
3, .	0.40	0.32	0.18	0.62	0.61	0.56	0.54	0.23	0.40	3, .	0.10	-	-	0.02	-	0.01	-	*	-
4, .	0.05	*	0.12	0.08	-	-	*	0.01	0.05	4, .	-	-	-	-	-	-	-	0.10	0.02
5, .	0.20	0.30	0.04	0.05	0.13	0.42	0.29	0.05	0.05	5, .	-	-	-	-	-	-	-	-	-
6, .	-	-	-	-	-	-	-	-	-	6, .	*	-	-	0.09	-	0.11	-	0.45	*
7, .	*	-	-	*	*	-	-	-	*	7, .	0.50	0.25	0.05	-	-	-	0.11	-	0.26
8, .	0.10	0.10	0.21	0.04	0.09	0.13	0.05	0.46	0.61	8, .	0.45	0.42	0.48	*	*	-	*	0.85	*
9, .	-	*	-	*	*	-	-	-	2.10	9, .	0.35	0.22	0.09	0.63	0.82	0.74	0.92	-	0.50
10, .	2.27	2.00	2.17	2.34	1.86	1.86	1.81	1.98	-	10, .	-	-	-	-	-	-	0.01	0.06	0.10
11, .	-	-	-	-	-	-	-	-	-	11, .	-	-	-	-	-	-	-	-	-
12, .	-	-	-	-	-	-	-	-	-	12, .	-	-	-	-	-	-	-	-	-
13, .	-	-	-	-	-	-	-	-	-	13, .	-	-	-	-	-	-	-	-	-
14, .	-	-	-	-	-	-	-	-	-	14, .	0.25	0.26	0.16	0.30	0.32	0.14	*	0.21	0.25
15, .	-	-	0.09	*	*	-	0.04	*	0.03	15, .	-	-	-	-	-	-	0.26	-	-
16, .	2.05	1.80	2.02	1.62	1.71	1.92	1.48	1.30	1.10	16, .	-	-	-	-	-	-	-	-	-
17, .	-	0.07	-	-	-	-	-	-	0.07	17, .	-	-	-	-	-	-	-	-	-
18, .	*	0.34	0.49	0.32	0.28	0.32	*	0.45	0.31	18, .	-	-	-	-	-	-	-	-	-
19, .	0.25	-	-	-	-	-	0.23	-	-	19, .	-	-	-	-	-	-	-	-	-
20, .	-	-	-	-	-	-	-	-	-	20, .	0.10	0.07	-	0.08	0.09	-	-	-	0.30
21, .	-	-	-	-	-	-	-	-	-	21, .	-	-	-	-	-	-	-	-	-
22, .	-	-	-	-	-	-	-	-	-	22, .	-	-	-	-	-	-	-	-	-
23, .	-	-	-	-	-	-	-	-	-	23, .	-	-	-	-	-	-	-	-	-
24, .	-	-	-	-	-	-	-	-	-	24, .	-	-	-	-	-	-	-	0.10	-
25, .	-	-	-	-	-	-	-	-	-	25, .	0.30	0.08	-	-	0.06	-	-	-	0.40
26, .	-	-	-	-	-	-	-	-	-	26, .	-	-	-	-	-	-	-	-	-
27, .	-	-	-	-	-	-	-	-	0.03	27, .	-	-	-	-	-	-	-	-	-
28, .	-	-	-	0.12	0.18	0.01	-	0.88	-	28, .	-	-	-	-	-	-	-	-	-
29, .	0.20	*	*	*	*	*	*	-	*	29, .	-	-	-	-	-	-	-	-	-
30, .	0.10	0.20	0.61	0.62	0.40	0.52	0.99	0.04	1.77	30, .	-	-	-	-	-	-	-	-	-
										31, .	-	-	-	-	-	-	-	-	-
Tot.,	5.82	5.51	6.11	5.81	5.26	5.74	5.52	5.44	6.52	Tot.,	2.15	1.39	0.78	1.14	1.29	1.04	1.30	1.77	1.86
Totals for Year, ...											45.58	45.17	41.63	41.90	42.27	34.98	42.31	39.18	42.44

* Precipitation included in that of following day.

Flow of Streams.

Judging by the flow of the Sudbury River, the year 1892 was the third in order of dryness in the past eighteen years, the flow during the year being 73 per cent. of the average. The dryer years were 1880 and 1883, when the corresponding percentages were respectively 54 and 50. The distribution of the flow during 1892 was such that by far the greater part of the deficiency, as compared with average years, occurred in February, March and April, while the flow during the remainder of the year, although somewhat below the average, was fairly well maintained. As a consequence, cities and towns deriving their supply from large watersheds from which water usually runs to waste in the spring did not experience any special inconvenience, while those communities deriving their supply from large ponds fed by small watersheds drew the ponds in many cases to a lower level than ever before. This result was due, as has already been mentioned, not only to the small flow of the streams during the early part of 1892, but also to the drought during the last seven months of 1891, which caused the ponds to be drawn to an unusually low level at the end of the year.

In order to show the relation between the flow of the Sudbury River during each month of 1892 and the normal flow of the same river, as deduced from fourteen years' observations from 1879 to 1892, inclusive, the following table has been prepared. The area of the watershed of the Sudbury River above the point of measurement is 75.2 square miles.

Table showing the Average Monthly Flow of Sudbury River for the Year 1892, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.

MONTH.	Normal Flow. Cubic Feet per Second per Square Mile.	Actual Flow in 1892. Cubic Feet per Second per Square Mile.	Excess or Deficiency. Cubic Feet per Second per Square Mile.
January,	2.218	2.893	+0.675
February,	3.247	1.459	—1.788
March,	4.097	3.025	—1.072
April,	2.926	1.348	—1.578
May,	1.618	1.947	+0.329
June,	0.740	0.662	—0.078
July,	0.282	0.331	+0.049
August,	0.441	0.434	—0.007
September,	0.451	0.355	—0.096
October,	0.821	0.194	—0.627
November,	1.163	1.079	—0.084
December,	1.436	0.750	—0.686
Average,	1.611	1.209	—0.402

The next table shows the weekly fluctuations, during 1892, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts.

Table showing the Average Weekly Flow of the Sudbury and Merrimack Rivers, in Cubic Feet per Second per Square Mile of Drainage Area, for the Year 1892.

Week ending Sunday.	Sudbury River. — Cubic Feet per Second per Square Mile.	Merrimack River. — Cubic Feet per Second per Square Mile.	Week ending Sunday.	Sudbury River. — Cubic Feet per Second per Square Mile.	Merrimack River. — Cubic Feet per Second per Square Mile.
Jan. 3,	2.146	2.405	July 3,	0.506	2.471
10,	1.720	2.059	10,	0.433	2.092
17,	3.973	2.783	17,	0.316	0.913
24,	3.829	2.839	24,	0.194	0.577
31,	1.679	1.626	31,	0.281	0.483
Feb. 7,	1.260	1.261	Aug. 7,	0.379	0.500
14,	1.248	1.210	14,	0.363	0.640
21,	1.118	1.230	21,	0.205	0.918
28,	2.150	1.226	28,	0.639	1.229
Mar. 6,	1.487	1.695	Sept. 4,	0.579	2.497
13,	4.522	1.914	11,	0.264	0.833
20,	2.016	1.592	18,	0.576	1.085
27,	3.904	1.552	25,	0.321	0.783
Apr. 3,	2.755	2.377	Oct. 2,	0.168	0.639
10,	1.868	3.423	9,	0.244	0.507
17,	1.171	1.656	16,	0.218	0.509
24,	1.003	1.198	23,	0.213	0.448
May 1,	0.847	1.256	30,	0.129	0.451
8,	1.103	1.581	Nov. 6,	0.334	0.588
15,	1.001	1.360	13,	1.029	1.124
22,	2.598	2.265	20,	1.926	2.879
29,	2.372	4.973	27,	0.884	1.918
June 5,	1.235	2.231	Dec. 4,	0.867	1.074
12,	0.739	1.305	11,	0.956	1.069
19,	0.627	0.892	18,	0.971	1.048
26,	0.385	0.852	25,	0.665	0.904

In the annual report of the State Board of Health for the year 1890 (pages 338–340) a table was printed giving records of the

rainfall upon the Sudbury River watershed, and its yield, expressed in inches in depth upon the watershed (inches of rainfall collected), for the sixteen years from 1875 to 1890, inclusive. The corresponding records for the years 1891 and 1892, as taken from the annual reports of the Boston Water Board, are given in the following table, also the average of the records for the whole eighteen years.

Rainfall Received and Collected on the Sudbury River Watershed.

MONTH.	1891.			1892.			MEAN FOR 18 YEARS, 1875-1892.		
	Rainfall.	Rainfall Collected.	Per Ct. Collected.	Rainfall.	Rainfall Collected.	Per Ct. Collected.	Rainfall.	Rainfall Collected.	Per Ct. Collected.
	Inches.	Inches.		Inches.	Inches.		Inches.	Inches.	
January,	7.020	5.383	76.69	5.850	3.335	57.01	4.430	2.307	52.08
February,	5.235	5.616	107.28	3.140	1.574	50.13	4.076	3.223	79.07
March,	6.475	7.944	122.69	4.060	3.488	85.90	4.655	5.097	109.49
April,	3.905	4.138	105.97	0.830	1.504	181.15	3.214	3.533	109.93
May,	2.010	1.039	51.70	5.585	2.245	40.20	3.269	1.957	59.87
June,	3.770	0.714	18.92	2.760	0.739	26.76	3.016	0.853	28.28
July,	3.395	0.266	7.83	4.230	0.382	9.03	3.788	0.335	8.84
August,	4.725	0.290	6.15	4.440	0.500	11.26	4.266	0.534	12.52
September,	2.380	0.350	14.71	2.840	0.396	13.94	3.163	0.450	14.23
October,	3.830	0.375	9.78	1.170	0.224	19.18	4.200	0.938	22.33
November,	3.090	0.526	17.03	5.800	1.204	20.75	4.144	1.537	37.09
December,	3.685	0.971	26.34	1.125	0.865	76.89	3.565	1.833	51.42
TOTALS AND AVERAGES,	49.520	27.612	55.76	41.830	16.456	39.34	45.786	22.599	49.36

The Sudbury River records are particularly valuable as a basis for estimating the yield of other watersheds in Massachusetts, both on account of the accuracy with which the measurements have been made during the whole eighteen years, and the absence of abnormal conditions which would unfavorably affect the results. It is therefore thought advisable to publish in the following table those portions of the records relating to the yield of this watershed for the whole eighteen years, and in doing so the flow from the watershed is expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yield of watersheds used as sources of water supply.

Yield of the Sudbury River Watershed in Gallons Per Day Per Square Mile.*

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Average for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av'ge for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000
May,	1,292,000	938,000	1,030,000	1,336,000	720,000	1,009,000
June,	529,000	300,000	417,000	426,000	203,000	414,000
July,	86,000	115,000	224,000	62,000	115,000	114,000
August,	55,000	78,000	257,000	240,000	94,000	214,000
September,	306,000	91,000	44,000	121,000	118,000	111,000
October,	299,000	186,000	83,000	336,000	146,000	190,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000
Average for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000
Av'ge for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000

MONTH.	1888.	1889.	1890.	1891.	1892.	Mean for 18 Years, 1875-1892, Inclusive.
January,	1,053,000	2,782,000	1,254,000	3,018,000	1,870,000	1,293,000
February,	1,951,000	1,195,000	1,529,000	3,486,000	943,000	1,981,000
March,	3,237,000	1,339,000	3,643,000	4,453,000	1,955,000	2,859,000
April,	2,645,000	1,410,000	1,875,000	2,397,000	871,000	2,047,000
May,	1,632,000	880,000	1,366,000	582,000	1,259,000	1,097,000
June,	422,000	653,000	568,000	414,000	428,000	494,000
July,	117,000	633,000	108,000	149,000	214,000	188,000
August,	380,000	1,432,000	132,000	163,000	280,000	299,000
September,	1,155,000	824,000	458,000	203,000	229,000	260,000
October,	1,999,000	1,230,000	2,272,000	210,000	126,000	526,000
November,	2,758,000	1,941,000	1,215,000	305,000	697,000	891,000
December,	3,043,000	2,241,000	997,000	544,000	485,000	1,028,000
Average for whole year,	1,697,000	1,383,000	1,285,000	1,315,000	781,000	1,075,000
Av'ge for driest six months,	953,000	944,000	747,000	239,000	327,000	406,000

* The area of the Sudbury River watershed used in making up these records included water surfaces amounting to about one per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about three per cent. in 1886. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

THE INTERPRETATION OF WATER ANALYSES.

By THOMAS M. DROWN, M.D.,
CHEMIST OF THE BOARD.

THE INTERPRETATION OF WATER ANALYSES.

By THOMAS M. DROWN, M.D., Chemist of the Board.

The value of a sanitary analysis of water rests on its interpretation. It has little in common with an analysis made for the purpose of determining specific substances. The result of an analysis of a mineral water, for instance, in which the amounts of various mineral substances are given, is a statement of fact which needs no interpretation. But in the case of a sanitary analysis the results must be considered in connection with a great number of conditions, such as locality and surroundings of the water, the season of the year, depth of lake or pond at which the sample is taken, and a great many more. To take one illustration only: an amount of chlorine in a water in one locality which would be without significance, would in another be an evidence of considerable pollution with sewage. It is the object of the present article to give very briefly the conditions governing this interpretation, and the reader is referred to an article on the same subject in the volume on the Examination of Water Supplies, 1890, in which the subject is treated at greater length.

The object of a sanitary analysis of water is to determine the amount of mineral and organic matter dissolved and suspended in the water, and also, as far as it is possible, to determine the character and condition of the organic matter. The microscope is a valuable aid in this connection, as it enables us to recognize forms of vegetable and animal life, and also at times the products of their disintegration and decomposition. The appearance of the water is also carefully noted, the amount and character of its permanent turbidity and sediment, and also its odor, both cold and hot.

Organic matter, both animal and vegetable, is composed mainly of carbon, hydrogen, nitrogen and oxygen, united in various proportions. Animal matter contains generally much more nitrogen

than vegetable matter, and decomposes more rapidly. By decomposition is meant the gradual oxidation of the carbon, hydrogen and nitrogen of the organic matter, whereby these elements are converted into carbonic acid, water, and nitric acid (nitrates). In this process of oxidation the carbon first combines with the oxygen, and ammonia (a combination of nitrogen and hydrogen) is formed. This ammonia is next oxidized, the hydrogen to water and the nitrogen first to nitrous acid (nitrites) and ultimately to nitric acid (nitrates). Carbonic acid, water and nitric acid are the final results of the complete oxidation or mineralization of the organic matter, while ammonia and nitrites are intermediate products, and represent decomposition in progress. These chemical changes are the result of the activity of micro-organisms, and do not take place in their absence.

Owing to the fact that many of the compounds of nitrogen can be determined with great accuracy and facility, it is usual to determine organic matter in water, and the extent of the change which it has undergone by decomposition, by means of the amount and condition of the nitrogen. Thus we determine the amount of the nitrogen existing in the organic matter which has not yet begun to decompose (organic nitrogen — albuminoid ammonia), the amount existing as ammonia, the amount in the form of nitrites, and the amount in the form of nitrates.

Other methods of determining organic matter in water are by means of the "oxygen consumed," when the water is treated with potassium permanganate, and by the "loss on ignition," when the solid residue of the evaporation is heated to dull redness. The "fixed residue" after ignition represents the amount of mineral matter in the water. The determination of chlorine expresses the amount of common salt in a water, and is a measure of the degree of pollution by sewage or house drainage, as will be subsequently described.*

The differences in surface and ground waters are so great and radical, the former containing always more or less vegetable and animal life, and the latter being (normally) free from life, it is necessary to consider the significance of the different determinations in these two classes of water separately.

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* For the methods of analysis, the reader is referred to the special reports of the Board on the Examination of Water Supplies, and the Purification of Sewage, 1890.

Albuminoid Ammonia.

Albuminoid ammonia represents the nitrogen in organic matter which has not yet begun to decompose by oxidation. As ordinarily determined by the methods of the State Board of Health, it is about one-half of the total nitrogen in the unaltered organic matter. It affords in itself no indication whether the source of the nitrogen is animal or vegetable matter. In surface waters which are unpolluted by sewage we find a very wide range in the amounts of albuminoid ammonia. Brown swampy waters always contain a large amount in solution, and waters with abundant vegetable growth have in addition a considerable amount in suspension. Following are a few instances, the average amount during many years, of albuminoid ammonia in unpolluted ponds and reservoirs: —

[Parts per 100,000.]

	Color.	Free Ammonia.	Albuminoid Ammonia.	
			Total.	Suspended.
Lenox, Storage Reservoir,	0.00	.0001	.0028	-
New Bedford Storage Reservoir,	1.36	.0015	.0248	.0018
Springfield, Ludlow Reservoir,	0.15	.0019	.0381	.0154
Leominster, Haynes Reservoir (average),	0.39	.0023	.0409	.0133
Leominster, Haynes Reservoir, August, 1887,	0.60	.0006	.1052	-
Lynn, Walden Pond,	1.21	.0058	.0615	.0212

An average analysis of Lawrence sewage shows 0.5302 part albuminoid ammonia, and 1.8202 parts of free ammonia per 100,000. It would therefore take more than 20 per cent. of sewage added to a pure body of water to raise the amount of albuminoid ammonia to the amount found in one instance in Haynes Reservoir. Instances might be multiplied to show that high albuminoid ammonia is in itself no evidence of sewage pollution. In most surface waters the source of the albuminoid ammonia is to be sought in organic matter derived from vegetable growths in the water, from vegetable débris in the bottoms of ponds and reservoirs, and also from swamps. In the latter case the water has a brown color. New Bedford water, cited above, is a good instance of a water highly colored with vegetable matter. Neither is high albuminoid ammonia, when accompanied with high free ammonia, necessarily indicative of sewage pollution.

The rapid decomposition of animal and vegetable matter, when in excessive amount, gives rise also to high free ammonia. Thus one analysis of water from Glen Lewis Pond, in Lynn, November, 1891, has .1060 part of free ammonia, with .0606 part of albuminoid ammonia. Considerable sewage pollution of a body of water is, nevertheless, accompanied by high free and albuminoid ammonia. Thus the average analysis of the highly polluted Blackstone River below Worcester for 1891 shows .3340 free ammonia and .1563 albuminoid ammonia. The point which it is desired to emphasize is that coincident high free and albuminoid ammonia do not necessarily indicate sewage pollution.

In good ground waters albuminoid ammonia is frequently entirely absent, and rarely exceeds .0025 part per 100,000. When it is much more than this, the excess may be due to an admixture of surface water, or to imperfect filtration. Thus the average albuminoid ammonia of the well at Ware was for two years .0011; for the wells at Eaton's Meadows, Malden, for 1891, .0007. Instances of imperfect filtration are seen in Wayland and Whitman, where filter-galleries alongside of ponds show respectively .0186 and .0188 albuminoid ammonia. In contrast with these cases of imperfect filtration may be mentioned the water in filter-gallery on the borders of the highly polluted Horn Pond in Woburn, in which the albuminoid ammonia is ordinarily only .0028 parts in 100,000.

When a ground water containing considerable nitrogen in the form of nitrates is exposed to light in open reservoirs, the conditions are particularly favorable for a rapid growth of algæ, which appear in the analysis as albuminoid ammonia. By reason of this exposure to the light, the ground water has become a surface water, and must be classified accordingly.

Free Ammonia.

Free ammonia is always a decomposition product of organic matter. In itself it is harmless mineral matter; its significance in water analysis rests on the fact that it may be accompanied by organic matter in the process of decomposition, or that it may indicate the presence of sewage, of which free ammonia is one of the characteristic ingredients.

In good clean ponds, unpolluted by sewage, the free ammonia is very rarely high, for as fast as it is formed by the decomposition of the vegetable and animal organisms in the water it is immediately appropriated by growing water plants.

For instance, the average of monthly determinations for two years of free ammonia in Watuppa Lake, Fall River (a light-colored water), was .0005 part per 100,000; in Reservoir 4 of the Boston Water Works (in a moderately dark-colored water), .0006 part; and in Acushnet Reservoir, New Bedford (a very dark-colored water), .0015 part per 100,000. In bodies of water which receive much sewage the free ammonia may be in much greater quantity than the plants can appropriate. Thus the average of free ammonia in Horn Pond, Woburn (which receives a large amount of wastes from tanneries), for two years was .0152 part per 100,000, and in Mystic Lake the amount was .0235 part.

The amount of free ammonia in the warmer months, when the vegetation is most active, is lower than in the colder months. Thus in Mystic Lake in August, 1888, the free ammonia was entirely absent, while in January of the same year it was .0573 part per 100,000. Even in clean, unpolluted ponds the free ammonia is generally higher in winter, although it seldom reaches any considerable amount. The highest winter free ammonia noticed in Reservoir 4 of the Boston Water Works, at a depth of one foot, was in January, 1891, when it was .0028 part. In reservoirs which have been flooded, without the removal of the soil and stumps of trees, the decomposition of the vegetable matter may be so rapid in summer that the free ammonia formed is greatly in excess of that which the plant growth can absorb. Glen Lewis Pond, Lynn, is a reservoir of this character. The average free ammonia for 1890 was .0412 part per 100,000; and in September of that year it was .1390 part.

The depth of the water has also an influence on the amount of free ammonia. The lower layers of deep ponds are stagnant in summer, and when the bottom contains much decomposable organic matter the oxygen is quickly exhausted, and putrefaction sets in with the formation of much free ammonia. In clean ponds and reservoirs this tendency is not strongly marked. For instance, the bottom stagnant layer of water of Reservoir 4 (a basin carefully cleaned before filling), at a depth of forty feet, rarely reaches .0050 part in free ammonia, while the bottom layer in Jamaica Pond, Boston (fifty feet from the surface), has been known to contain nearly .5000 part per 100,000.* This condition of affairs is apt to occur also when the supply of oxygen is shut off from a water which contains much

* This subject was fully discussed in the volume Examination of Water Supplies, 1890, page 749.

decomposable organic matter, as, for instance, when a stream or pond is for a long time covered with ice.

The significance of free ammonia in ground waters is of entirely different character from that in surface waters, owing to the fact that no green growth can take place in the absence of light. The oxidation of the nitrogen of ammonia to nitric acid goes on so rapidly in the pores of the ground near the surface where air is abundant, that it is unusual to find any unoxidized nitrogen in natural ground waters. That is to say, the nitrogen in these waters is usually entirely oxidized, and appears in the form of nitrates. The presence of free ammonia in a ground water is an indication of imperfect purification of a water which has contained organic matter. As instances may be taken the water of wells at Eaton's Meadows, above cited, which shows by its high nitrates that the water originally contained a large amount of nitrogen in the form of organic matter or ammonia, and the water of the well in Stoughton, which is likewise high in nitrates. In the first instance free ammonia is almost always absent, averaging .0002 part for a year, while in the latter it is almost always present, averaging .0013 part for a year. Many house wells in close proximity to cesspools contain very high free ammonia, as the result of incomplete oxidation of the ammonia in the passage of the foul water through the ground.

But while we generally refer the presence of free ammonia to imperfect oxidation of organic matter of house drainage or sewage, there are cases in which the ammonia has its origin in vegetable organic matter in the ground itself. Thus the water of the filter-gallery on the shores of the storage reservoir of the Wayland Water Works always contains considerable free ammonia, while the water in the reservoir contains very little. There are several cases of like character in the State, and they are all associated with iron oxide and the fungus *Crenothrix*. The existence of organic matter and sesquioxide of iron in the soil together, in the absence of oxygen, are the favorable conditions for the oxidation of the organic matter by the oxide of iron (with the formation of ammonia), the development of *Crenothrix*, and the solution of the iron in the form of protoxide, which separates out in the form of iron rust when the water is exposed to the air. Many wells sunk in swampy regions and in ferruginous river silt show the same phenomena.

Continuous pumping of new wells in these situations is frequently followed by a gradual increase of free ammonia and iron in solution,

as the result of drawing water from these ferruginous organic deposits. The odor of these waters is often disagreeable from dissolved sulphuretted and carburetted hydrogen.

The water from deep artesian wells not infrequently contains considerable free ammonia. Its origin is not always known, but the topographical and geological conditions preclude the possibility of this free ammonia having any connection with sewage pollution. This ammonia in some cases is associated with coal deposits, which always contain nitrogen. Other geological formations also contain organic matters, and may give rise to ammonia. There is no free oxygen in deep waters, and consequently no possibility of the ammonia becoming oxidized to nitrates.

Rainwater always contains considerable ammonia which it washes out of the atmosphere. A sample collected at Lawrence, October, 1888, had .0414 part, and a sample of snow collected at Jamaica Plain, Boston, December, 1887, .0258 part, per 100,000. The atmosphere of cities contains much more ammonia or other impurities than in the open country, and the rain or snow first falling is always the most impure.

Rainwater stored in cisterns generally retains its free ammonia.

Nitrites.

Nitrous acid (forming nitrites when combined with bases such as potash, soda or lime) is an intermediate product of oxidation of the nitrogen of ammonia. In unpolluted surface waters it is generally absent, or present only in very minute amount, rarely exceeding a yearly average of .0002 part per 100,000. In waters which receive sewage, or highly nitrogenous manufacturing refuse, however, the amount of nitrogen in the form of nitrites is considerably higher. The average for Horn Pond was, for 1891, .0009 part, for Abbajona River .0021 part, for Mystic Lake .0012 part, for the Blackstone River below Worcester .0032 part, and for the Neponset River at Hyde Park, during 1887–89, .0082 part, per 100,000. High nitrites in a surface water, say above .0005 part, together with high free ammonia, is an evidence of considerable sewage pollution.

In good ground waters nitrites are always absent. When nitrogen is present in this form in a ground water it is an evidence that the oxidizing capacity of the earth through which the water percolates is insufficient to oxidize completely the nitrogen it contains. As in the case of surface waters, coincident high nitrites and ammonia in

a ground water point to pollution by sewage or house drainage, which has not been completely purified by filtration.

Nitrates.

Nitric acid is the completely oxidized form of nitrogen. In waters it is combined with alkalies or with lime, forming nitrates. Potassium nitrate is ordinary saltpetre. One might expect that this mineralized condition of nitrogen would accumulate in waters. But, like ammonia, it is a plant food, and in surface waters it is quickly taken up by growing plants. Hence, in good unpolluted ponds and reservoirs the nitrates are always low and often absent. They are lower in the warmer months, when the vegetation is most active. Middleton Pond, an unpolluted body of water, had an average contents of nitrogen as nitrates during 1891 of .0053 part per 100,000, the highest amount being .0200 part in March; in September and October nitrates were entirely absent in this water. In Horn Pond, which is highly polluted, the average contents of nitrates were in 1891 .0502 part, the highest, .1000 part, occurring in January, and the lowest, .0050 part, in August. Stacy's Brook, in Swampscott, a very highly polluted stream, had an average of .1149 nitrates for two years, the highest being .4000 part.

In unpolluted ground waters the nitrates are also very low. The source of nitrates in these waters is decomposing surface vegetation. Vegetable matter, such as leaves, grasses, mosses and peat, are not highly nitrogenous, and, moreover, decompose very slowly. The ammonia and nitrates are largely taken up by the roots of plants, and but little nitrogen in the form of nitrates penetrates into the ground water. A good illustration is found in the water of the well of the Mansfield Water Works, in which the average of four determinations for a year gave only .0083 part of nitrogen as nitrates, the lowest being .0050 part and the highest .0120 part, per 100,000. In striking contrast to this is the water of wells situated in populous regions, in which the drainage from houses and cesspools is oxidized in its passage through the ground, and the nitrates accumulate in the ground water. The amount of nitrogen as nitrates in the water of the wells at Eaton's Meadows is about .5000 part, and is remarkably constant. The nitrates in the well at Stoughton are still higher, namely, .8280 part, and the spring waters of Everett contain from 0.4000 to 1.1500 parts per 100,000. Nitrates when present in these large amounts represent considerable previous

pollution of the water by sewage (or its equivalent in house drainage); but as far as the nitrates themselves are concerned they indicate complete oxidation of organic matter to harmless mineral matter. When high nitrates are associated with free ammonia or with nitrites, it is an evidence that the oxidation of organic matter is incomplete.

The effect of exposing water high in nitrates to light in open reservoirs has already been referred to. The rapid growth of algæ which takes place under these conditions is generally accompanied by disagreeable tastes and odors.

Chlorine.

It has been found within the State of Massachusetts that the amount of chlorine (indicating the amount of common salt) in waters of streams and ponds in uninhabited drainage areas is tolerably constant in each locality. This amount decreases from the seaboard westward, and there is sufficient evidence to prove that the chlorine in the unpolluted waters of Massachusetts has its source in the sea, and is carried inland by easterly winds. By placing on the map of the State the amount of chlorine normally present in its unpolluted waters, and then connecting the points of equal amounts, lines of like chlorine contents are obtained which are called isochlors. In the volume of Examination of Water Supplies, 1890, and in the Twenty-second Annual Report of the Board, this map is given. From it will be seen that the waters near the coast contain normally about .65 part of chlorine per 100,000, and in the western part of the State the amount sinks to less than .10 part.

The application of this map as a test of pollution is very simple. Having determined the amount of chlorine in a water, this is compared with the amount which the normal or unpolluted waters of the region contains. Any considerable excess above this normal is an evidence and measure of the amount of pollution, which, directly or indirectly, the water has received.

In the case of the nitrogen compounds in water, it has been noted that they may undergo many transformations, but with common salt there is no change in its amount or character, either in surface or ground waters. A highly polluted water may be completely purified by filtration through the ground, but the chlorine remains to tell the tale of its origin. High nitrates in ground waters are

always accompanied by an amount of chlorine which is much above the normal. A fuller discussion of the subject of normal chlorine may be found in the volume of the Examination of Water Supplies, pages 542–545, 679–682.

Oxygen Consumed.

When a solution of potassium permanganate is added to a water containing organic matter, a certain amount will be decolorized, showing that the permanganate has parted with some of its oxygen in oxidizing the carbon of the organic matter. There are various methods of conducting this process; the one used in the work of the State Board of Health is that known as Kubel's, in which the water is boiled with the permanganate for a definite time, about five minutes. The amount of oxygen that the permanganate gives up under these conditions is recorded as the "oxygen consumed" by the organic matter in the water. It is only the carbon of the organic matter that is thus oxidized, and only an indeterminate amount of this carbon. Different organic compounds behave very differently when thus treated, and the determination has therefore no precise value. It is mainly in comparing waters of the same character, or in comparing sewage or other polluted liquids with the effluents derived from their purification, that it has its principal value. The determination is also of value as applied to well waters. A good ground water seldom has a higher "oxygen consumed" than .0100 part per 100,000. When it is considerably more than this, it indicates carbonaceous impurity in the water.

Hardness.

The hardness of a water, as expressed in a water analysis, is the amount of soap-curdling substance equivalent to a like amount of carbonate of lime. Thus a hardness of two means that the water has a hardness which would be produced by two parts of carbonate of lime in 100,000 of water. High hardness in a water is ordinarily caused by lime and magnesia which the water has dissolved from rocks, or by the infiltration of sea water which also contains lime and magnesia. In localities where the hardness could not be derived from these sources it has its origin probably in sewage contamination. Unpolluted waters in Massachusetts, except in the extreme western portion, have a hardness of five-tenths to two parts.

Iron.

It was mentioned above in connection with free ammonia that many ground waters contain iron in sufficient amount to produce a rusty precipitate when the water is exposed to the air and the iron oxidized. This amount of iron unfits a water for domestic use. Surface waters rarely contain much iron in solution. The brown swampy waters contain usually the most. When these waters are bleached by exposure to the sun, the iron is precipitated; but under ordinary circumstances this does not take place. When a ground water contains .0500 part of metallic iron per 100,000 in solution, it will generally precipitate on standing. The determination is of special importance in the case of new ground water supplies, for a constant increase, on continued pumping, even though the amount may be very small at first, points to a time when the amount of iron will become excessive.

Some ground waters contain also considerable manganese, which is dissolved from the ground under the same conditions that cause the solution of iron.

Color.

The color of surface waters is mainly due to organic coloring matter which the water has dissolved from leaves, grasses, mosses, peat, etc., particularly where the water flows sluggishly through swamps. The standard of measurement has been described in the Methods of Analysis, in the volume on the Examination of Water Supplies. The average color of Boston water is about 0.35, of New Bedford water 1.36, of Wenham Lake 0.05, of the Plymouth ponds 0. Ground water is ordinarily colorless. A notable exception is the dark brown water from wells in Provincetown, which penetrate a peaty layer under the sand. Ground water containing iron in solution acquires a reddish-brown color when the iron begins to oxidize. The water under these conditions assumes a milky appearance. Ultimately, however, this very fine suspended iron oxide separates out, and the water becomes again colorless.

Odor.

The cause of the odor in waters had a full discussion in the volume on Examination of Water Supplies. Some further facts have been obtained since that volume appeared, but our information on the subject is far from being as full as we could wish. A notable

addition to the subject will be found in the Twenty-third Annual Report of the Board, in Mr. Calkins' article on *Uroglena*, an infusorian which communicates a decided oily odor to waters, and is much more abundant in ponds than has been generally supposed. There is now no difficulty in recognizing its characteristic odor, especially when water containing it is heated.

The fishy odor so often complained of in surface waters is generally due to infusoria. The diatom, Asterionella, is also easily recognized by its characteristic aromatic odor, when present in considerable amount.*

Turbidity and Sediment.

The permanent turbidity and sediment of a water are observed in the large clear white glass bottles in which the water is collected, after standing over night. The character of the turbidity, whether floating algæ or clayey matter, or the milkiness which occurs in water containing much iron or sewage, is noted, and also its amount. The amount and character of the sediment on the bottom of the bottle is also recorded, — whether earthy, flocculent, fibrous, etc.

Residue on Evaporation.

When water is evaporated to dryness, a solid residue remains, which consists of the matters, mineral or organic, which were dissolved in the water, and also the suspended matters, if the water had not previously been filtered. In good ground waters this residue is white. In surface waters the residue may be more or less brown from dissolved organic matter. If this brown residue is heated to dull redness under carefully controlled conditions (see Methods of Analysis, in Examination of Water Supplies, 1890), the organic matter is burned off, and this "loss on ignition" represents the amount of organic matter in the water. It is only an approximate determination at the best, but not without value with soft surface waters. This "loss on ignition" is not obtained with ground waters, as the result would be meaningless as a determination of organic matter.

The residue after burning off the organic matter in surface waters is the fixed residue, or total contents of mineral matter in the water. In ground waters the residue on evaporation, without ignition, is recorded as the total mineral matter.

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* An article in a subsequent portion of this volume by Mr. Calkins treats at length of the connection between the odors of waters and the organisms they contain.

ON THE

AMOUNT OF DISSOLVED OXYGEN

CONTAINED IN THE

WATER OF PONDS AND RESERVOIRS

AT

DIFFERENT DEPTHS

IN WINTER, UNDER THE ICE.

BY THOMAS M. DROWN, M.D., CHEMIST OF THE BOARD.

ON THE AMOUNT OF DISSOLVED OXYGEN CONTAINED IN THE WATER OF PONDS AND RESERVOIRS AT DIFFERENT DEPTHS IN WINTER, UNDER THE ICE.

By Thomas M. Drown, M.D., Chemist of the Board.

In the twenty-third annual report of the Board (for the year ending Sept. 30, 1891) there were given the results of determinations of the amount of dissolved oxygen in ponds and reservoirs at different depths during the summer months. There is during the warmer months of the year a stagnant layer of water in all deep ponds, below the level to which the wind acts in disturbing the water near the surface; and also in very shallow ponds there may be a temporarily stagnant layer between the times at which the wind makes a perceptible disturbance of the surface. It was shown, as the result of this summer investigation, that the waters of ponds or reservoirs below the level at which they can receive oxygen by direct contact with air lose their contents of free dissolved oxygen very rapidly if the waters contain much readily decomposable organic matter, or if the bottoms of the ponds are foul with decaying organic matter. When the oxygen is exhausted and no more is obtainable, until the water turns over in the fall as the surface becomes cooler, processes of putrefaction set in, which make the water very offensive. On the other hand, when the waters contain but little organic matter, the free oxygen in the water may not be exhausted during the entire summer. The deep layers of water in a clean reservoir were found to be in good condition as late as August 20, with over fifteen per cent. of its original oxygen contents still remaining.

It seemed desirable to make a parallel series of determinations during the winter, when the supply of air from the surface is shut off by the ice. The winter of 1892–93 proved very favorable for this purpose, as there was a continuous coating of ice on the ponds

and reservoirs in Massachusetts from early in December until the determinations were made, in January, February and March.

Since the activity of the micro-organisms which govern the processes of decay in nature is much less pronounced in cold than in warm weather, we should not expect that the exclusion of air from a body of water in winter would be so speedily felt in the exhaustion of the free oxygen as in summer. Further, the amount of oxygen originally dissolved in water in winter is greater than in summer, owing to the fact that the capacity of water for dissolving gases decreases as the temperature rises. In general, however, the results of the summer investigations are confirmed by those in winter; namely, that the exclusion of air from the water is followed by a diminution of the dissolved oxygen in direct proportion to the decomposable organic matter present, reinforcing the argument for the storing of clean water in clean reservoirs.*

In the following tables of results the amount of oxygen present is expressed as a percentage of the amount required to saturate the water at the temperature when collected.

In all cases the lowest depth given was as near the bottom as samples could be pumped without drawing mud or sand into the tube.

Dissolved Oxygen at Different Depths in Jamaica Pond, Boston.

Jan. 24, 1893.

Depth.	Temperature of Water. — Centigrade Degrees.	Amount of Oxygen present in the Water expressed in Percentage of that required to saturate the Water at the Observed Temperature.
Just under the ice,	0	97.5
10 feet below surface of ice,	2	100.0
20 " " " "	2.1	89.2
30 " " " "	2.3	72.3
40 " " " "	2.2	19.2
44 " " " "	2.2	0

The odor of the sample nearest the bottom was very disagreeable, of that at forty feet faintly disagreeable, of the others none. The

* Perhaps as pronounced a case of the evil effects of an ice coating on a polluted stream as has been recorded is that of the Schuylkill River, which is the main water supply of Philadelphia. During the cold winter of 1882-83 Prof. A. R. Leeds found the bad odor of the water to be due to the presence of sulphuretted and carburetted hydrogen, which were formed from the organic matter after the free oxygen in the water had been exhausted.

ice was eight to nine inches thick on the pond, and was the second crop, the first ice formed having been cut by the Jamaica Pond Ice Company.

Dissolved Oxygen in Glen Lewis Pond, Lynn.

Jan. 26, 1893.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Just under the ice,	2.8	7.2
5 feet below surface of ice,	3.3	6.1

This pond had been frozen over for five or six weeks, and the ice was eighteen inches thick. The odor of both samples was decidedly disagreeable.

Dissolved Oxygen in Walden Pond, Lynn.

Jan. 26, 1893.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Just under the ice,	3.8	64.1
5 feet below surface of ice,	3.8	25.8
10 " " " "	3.5	19.6
15 " " " "	2.8	23.6

Walden Pond receives a portion of its water from Glen Lewis Pond. The ice was sixteen inches thick. The odor of the bottom sample was decidedly disagreeable.

Dissolved Oxygen in Basin 2, Boston Water Works.

Jan. 30, 1893.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Just under the ice,	1.2	85.5
5 feet below surface of ice,	1.3	78.7
10 " " " "	1.5	31.6

The ice was fifteen inches thick. There was no odor in any of the samples when collected.

Chemical Analysis of the Above Water at the Depth of Ten Feet.

[Parts per 100,000.]

Number.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.
							Albuminoid.								
	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	In Solution.	In Suspension.		Nitrates.	Nitrites.			
9953	Slight.	Slight, sandy	1.20	6.15	2.05	.0050	.0238	.0216	.0022	.42	.0090	.0001	2.7	.0290	.9125

Odor, none; when heated, decidedly unpleasant.

Dissolved Oxygen in Basin 3, Boston Water Works.

Jan. 30, 1893.

Depth.	Temperature. Centigrade Degrees.	Percentage of Oxygen.
Just under the ice,	2.2	81.4
5 feet below surface of ice,	2.1	61.8
10 " " " "	2.1	44.9
14 " " " "	2.3	43.9

The ice was fifteen inches thick. There was no odor in any of the samples when collected.

Chemical Analysis of the Above Water at the Depth of Fourteen Feet.

[Parts per 100,000.]

Number.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.
							Albuminoid.								
	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	In Solution.	In Suspension.		Nitrates.	Nitrites.			
9954	Slight.	Slight.	1.00	6.90	2.45	.0078	.0250	.0224	.0026	.54	.0150	.0001	2.6	.0250	.9125

Odor, none; when heated, decidedly unpleasant.

Dissolved Oxygen in Basin 4, Boston Water Works.

Feb. 14, 1893.

Depth.	Temperature.	Percentage of Oxygen.
Just under the ice,	0	100.
10 feet below the surface of ice,	3.4	100.
20 " " " " "	3.8	92.2
25 " " " " "	3.9	78.2
30 " " " " "	3.7	60.2

The ice was nine to ten inches thick. There was no odor in any of the samples when collected.

Chemical Analysis of the Above Water at a Depth of Thirty Feet.

[Parts per 100,000.]

Number.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.
	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. In Solution.	Albuminoid. In Suspension.		Nitrates.	Nitrites.			
10011	Slight.	Slight.	1.00	5.15	2.15	.0042	.0206	.0190	.0016	.32	.0180	.0000	2.0	.0190	.8235

Odor, none; when heated, distinctly disagreeable.

Dissolved Oxygen in Lake Cochituate, Boston Water Works.

Feb. 14. 1893.

Depth.	Temperature. Centigrade Degrees.	Percentage of Oxygen.
Just under the ice,	0	100.
10 feet below surface of ice,	3.8	100.
20 " " " "	2.8	99.7
30 " " " "	2.8	94.1
40 " " " "	2.8	82.5
45 " " " "	2.8	60.1
50 " " " "	2.9	49.2
55 " " " "	2.6	36.8

The ice was about 12 inches thick. There was no odor in any of the samples when collected.

Chemical Analysis of the Above Water at a Depth of Fifty-five Feet.

[Parts per 100,000.]

Number.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.
							Albuminoid.								
	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	In Solution.	In Suspension.		Nitrates.	Nitrites.			
10010	Decided.	Cons., rusty.	0.40	5.75	1.70	.0190	.0178	.0152	.0026	.56	.0150	.0001	2.9	.0325	.2557

Odor, none; when heated, distinctly disagreeable.

Dissolved Oxygen in Mystic Lake, Boston Water Works.

March 8, 1893.

Depth.	Temperature.	Percentage of Oxygen.
Just below the ice,	0.0	60.4
10 feet below surface of ice,	1.2	63.9
20 " " " "	2.1	68.4
30 " " " "	2.2	58.2
40 " " " "	2.2	55.1
50 " " " "	2.2	50.3
54 " " " "	2.4	49.1
60 " " " "	2.4	42.7
64 " " " "	2.4	25.1
66 " " " "	2.7	13.0
68 " " " "	2.7	0.0
74 " " " "	2.7	0.0

The ice was fifteen inches thick, and covered by eight inches of compact snow. The odor of the samples at sixty-eight and seventy-four feet was offensive.

Chemical Analyses of Water from Different Depths in Mystic Lake.

[Parts per 100,000.]

Number.	Depth.	Appearance.			Odor.		Residue on Evaporation.	
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.
10095	Just under the ice, . . .	Distinct, milky.	V. slight.	0.20	Faintly disagreeable.	Distinctly fishy.	11.95	2.25
10096	20 feet below surface, . .	Slight.	V. slight.	0.04	V. faint or none.	V. faint or none.	15.30	2.80
10097	54 feet below surface, . .	Slight.	Slight.	0.07	V. faintly unpleasant.	V. faint or none.	16.95	2.80
10098	74 feet below surface, . .	Distinct, milky.	V. slight.	0.65	Offensive.	Offensive.	17.50	3.05

Chemical Analyses of Water from Different Depths in Mystic Lake — Concluded.

[Parts per 100,000.]

Number.	Depth.	Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.	Manganese.
		Free.	Albuminoid. Total.	Albuminoid. In Solution.	Albuminoid. In Suspension.		Nitrates.	Nitrites.				
10095	Just under the ice, . . .	.0800	.0218	.0192	.0026	2.26	.0600	.0005	4.7	.0080	.3384	-
10096	20 feet below surface, . .	.0160	.0136	.0118	.0018	3.20	.0550	.0001	5.0	.0000	.1872	-
10097	54 feet below surface, . .	.1120	.0130	.0118	.0012	3.44	.0600	.0003	6.1	.0020	.1548	-
10098	74 feet below surface, . .	.3840	.0364	.0214	.0150	3.40	.0070	.0000	7.9	.2100	.3463	.7800
										*.0770	*.3168	

* The second determinations of iron and oxygen consumed were made on the water after filtering through paper in the laboratory.

It is of interest to note, in this series of analyses, that the water deteriorates in quality from a depth of twenty feet downwards, and also that the water directly under the ice contains more organic matter than that at greater depths, almost as much, in fact, as the water near the bottom. This is to be explained no doubt by the fact that in the purification of the water by slow freezing the organic matter which was present in this water accumulates immediately under the ice.

The odor in the upper layer was disagreeable and fishy from minute vegetable or animal organisms, but it did not have the offensive odor of putrefaction which characterized the water near the bottom, in which there was no oxygen.

Dissolved Oxygen in Brockton Reservoir.

March 15, 1893.

Depth.	Temperature. — Centigrade Degrees.	Percentage of Oxygen.
Just below the ice,	0.0	89.8
5 feet below the surface of ice,	3.0	79.9
10 " " " "	4.0	60.2
12 " " " "	3.9	28.0
14 " " " "	3.9	20.4
16 " " " "	3.9	3.8
18 " " " "	3.3	0.0

The ice was twelve inches thick, and covered with two inches of compact snow. The odor of the bottom sample was decidedly disagreeable when collected. The odor disappeared on standing.

Chemical Analyses of Water from Different Depths in Brockton Reservoir.

[Parts per 100,000.]

Number.	Appearance.			Odor.		Residue on Evaporation.	
	Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Loss on Ignition.
10128*	Very slight.	Very slight.	0.48	Very faintly vegetable.	Dist'ly veg'ble, peculiar.	2.75	1.00
10129†	Very slight.	Slight.	0.80	F'tly vegetable, somewhat unpleasant.	Dist'ly veg'ble, peculiar.	4.50	1.60
10130‡	Decided, yellow, rusty.	H'y, precipitate of iron oxide.	1.50	Disagreeable.	Very faint or none.	6.45	2.00

* One foot below the surface. † Ten feet below the surface. ‡ Eighteen feet below the surface.

Chemical Analyses of Water from Different Depths in Brockton Reservoir — Concluded.

[Parts per 100,000.]

Number.	Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	Oxygen Consumed.	Manganese.
	Free.	Albuminoid. Total.	Albuminoid. In Solution.	Albuminoid. In Suspension.		Nitrates.	Nitrites.				
10128*	.0020	.0132	.0086	.0046	.35	.0000	.0000	0.9	.0090	.5239	-
10129†	.0046	.0226	.0202	.0024	.53	.0070	.0002	1.9	.0225	.7829	-
10130‡	.0480	.0288	.0238	.0050	.53	.0050	.0008	1.9	.6600 §.1950	.9383	.0860

* One foot below the surface. † Ten feet below the surface. ‡ Eighteen feet below the surface.
§ The second determination was made on the water after filtering through paper in the laboratory.

Comparison by Depths of the Amount of Dissolved Oxygen in the Nine Ponds and Reservoirs Examined.

[Per cent. of saturation.]

Depth.—Feet.	Glen Lewis Pond.	Basin 2.	Basin 3.	Walden Pond.	Brockton Reservoir.	Basin 4.	Jamaica Pond.	Lake Cochituate.	Mystic Lake.
0, ...	2.8	85.5	81.4	64.1	89.8	100.0	97.5	100.0	60.4
5, ...	3.3	78.7	61.8	25.8	70.9	-	100.0	-	-
10, ...	-	31.6	44.9	19.6	60.2	100.0	-	100.0	63.9
12, ...	-	-	-	-	28.0	-	-	-	-
14, ...	-	-	43.9	23.6	20.4	-	-	-	-
16, ...	-	-	-	-	3.8	-	-	-	-
18, ...	-	-	-	-	0.0	-	-	-	-
20, ...	-	-	-	-	-	92.2	89.2	99.7	68.4
25, ...	-	-	-	-	-	78.2	-	-	-
30, ...	-	-	-	-	-	60.2	72.3	94.1	52.8
40, ...	-	-	-	-	-	-	19.4	82.5	55.1
45, ...	-	-	-	-	-	-	0.0	60.1	-
50, ...	-	-	-	-	-	-	-	49.2	50.3
55, ...	-	-	-	-	-	-	-	36.8	49.1
60, ...	-	-	-	-	-	-	-	-	42.7
64, ...	-	-	-	-	-	-	-	-	25.1
66, ...	-	-	-	-	-	-	-	-	13.0
68, ...	-	-	-	-	-	-	-	-	0.0
74, ...	-	-	-	-	-	-	-	-	0.0

From this table it would appear that it is the character of the bottom of the pond, rather than the organic matter in solution and suspension in the water, which determines the amount of oxygen remaining in solution. Basin 4 has been repeatedly cited as a striking instance of the advantage of removing all organic matter from the bottom and sides of a reservoir before filling. The oxygen was not exhausted in the water at the bottom of this reservoir, either in summer when the bottom layer was stagnant, or in winter under a covering of ice; and in none of the other ponds or reservoirs in this series was the amount of oxygen near the bottom so high as in Basin 4. In Glen Lewis Pond there was only about five feet of water, and the oxygen was nearly exhausted in the whole body of water. In only three of the bodies of water examined was the oxygen entirely absent at the bottom: namely, Mystic Lake, Jamaica Pond and Brockton Reservoir. The bottoms of first two are known to be foul, and one would expect that the oxygen in the lower layers would be soon exhausted when the supply of air was shut off. In the case of the Brockton Reservoir it must be vegetable decomposing matter which consumed the oxygen. The brook supplying this

reservoir flows through low, swampy regions, but does not receive the drainage of any considerable population.

In summer it was noticed that the surface of the stagnant layer was in some ponds sharply defined. Thus, in Lake Cochituate there was on Aug. 17, 1891, at forty feet below the surface, about 21 per cent. of free oxygen, and only 1.65 per cent. at forty-five feet. In Basin 3 there was 59 per cent. at twelve feet below the surface, and none at fourteen feet. Under the ice in winter these abrupt changes have not been noticed, but there is a gradual falling off of the oxygen from the top to the bottom of the pond.

In none of the ponds and reservoirs examined was there a serious deterioration of the quality of the water by reason of the exhaustion of the free oxygen, except very near the bottom, and then only in those bodies of water in which the bottoms contained much decomposing organic matter.

The method used in determining the dissolved oxygen was that of L. W. Winkler, described in the volume on the Purification of Sewage and Water, 1890. Winkler's original article appeared in the "Berichte," vol. 21, p. 2843.

All the determinations were made by Dr. A. H. Gill of the chemical department of the Massachusetts Institute of Technology.

ON THE MINERAL CONTENTS

OF

SOME NATURAL WATERS

IN

MASSACHUSETTS.

By THOMAS M. DROWN, M.D.,
CHEMIST OF THE BOARD.

ON THE MINERAL CONTENTS OF SOME NATURAL WATERS IN MASSACHUSETTS.

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In the usual sanitary analysis of water the total amount of mineral matter present is expressed as the "fixed residue" when the water is evaporated to dryness. But the composition of this fixed residue is not generally determined, inasmuch as the object of a sanitary analysis is rather to learn the amount, origin and condition of the organic matter. The hardness of a water (or its capacity of curdling soap), which is generally included in a sanitary analysis, expresses in a general way the amount of lime and magnesia present, but the direct determination of these substances is not made.

A complete analysis of the mineral contents of a water involves tedious methods of analysis, and the information thus obtained has, generally, no sanitary significance. The presence of a large amount of lime and magnesia in a water, it is true, often causes temporary inconvenience to those accustomed to soft water; but there is no evidence to prove that the regular use of hard water for drinking is in any way injurious.

The amount of mineral matter in solution in the normal waters of Massachusetts is very small. Except in a small section of the western part of the State there is little or no limestone in Massachusetts, and the older rocks and their débris are but slightly attacked by natural waters.

Following is the amount of fixed residue, or mineral matter in solution, in a number of normal surface and ground waters used for water supplies in Massachusetts. The amounts given represent, in most cases, the average of a large number of closely agreeing determinations: —

[Parts per 100,000.]

Surface Waters.					Ground Waters.				
Cold Spring Brook, Ashland.	Middleton Pond, Middleton.	Scott Reservoir, Fitchburg.	Tatnuck Brook Reservoir, Worcester.	Haynes Reservoir, Leominster.	Well, Plymouth.	Springs, Amherst.	Well, Mansfield.	Springs, Uxbridge.	Spring, Agawam.
2.57	2.10	2.50	1.36	1.20	3.60	2.98	2.73	2.53	3.14

The average mineral contents of the ground waters, namely, 3 parts per 100,000, is, as might be expected, somewhat higher than the surface waters, which is only about 2 parts. But the former amount, namely, 3 parts per 100,000, or 1.74 grains per gallon, is much less than is found in most water supplies. Waters of this character are only found in regions where the rocks resist the action of water, and where, also, there is little or no population on the drainage areas.

The mineral substances present in these waters, as will be seen by the table of analyses which follows, are lime, magnesia, alumina, potash, soda and oxide of iron, combined with silica, carbonic acid, sulphuric acid and chlorine.

When the amount of solids in waters in Massachusetts is decidedly higher than the average above given, the increase of mineral matter may be due to sewage or house drainage, to infiltration of sea water in localities near the coast, to the presence of iron dissolved out of the soil by organic matter, or, in limestone regions, to the presence of lime.

In selecting the waters in which the mineral contents were to be determined, it was thought desirable to study the various influences which affect the amount and character of this mineral matter, such

MINERAL ANALYSES OF WATERS IN MASSACHUSETTS.

Normal Ground Waters.

[Parts per 100,000.]

		Lime (Ca O).	Magnesia (Mg O).	Oxide of Iron (Fe O).	Oxide of Manganese (Mn O).
1	Mansfield, well, ...	0.306	0.0954	0.0013	0.0
2	Framingham, spring north-east of sewage fields,	0.143	0.0626	0.0039	0.0
	Large Population on Drainage Area.				
3	Stoughton, well, ...	3.195	0.978	0.0730	0.0388
4	Everett, spring, ...	2.947	1.176	0.0	0.0
5	Malden, tubular wells, ...	3.765	1.457	0.0	0.0
	Proximity of Sewage Fields.				
6	Framingham, spring north-west of sewage fields,	1.341	0.332	0.0	0.0

as the amount of population on the drainage area, the influence of sewage filtration fields, the presence of organic matter and iron in the ground, the proximity of the sea, and also the results of imperfect filtration of water from a surface source into an adjacent filter-gallery.

The actual determinations were limited to the lime, magnesia, alumina, oxide of iron, manganese, silica, chlorine and sulphuric acid. Qualitative chemical and spectroscopic tests showed the presence of sodium in all the waters in considerable quantity, and potassium in most cases in smaller amounts. The residues of evaporation of all the waters, with the exception of that from Reading, effervesced more or less when treated with acids, showing the presence of carbonates. A few of the ground waters were found to contain lithium.

The total amount of mineral matter given in the tables is the average of many determinations made in the course of the regular sanitary analyses of these waters, and is not the amount in the samples under examination. The chlorine and iron oxide are also in some cases averages of many determinations.

The sanitary analyses of many of these waters are added for purposes of comparison.

MINERAL ANALYSES OF WATERS IN MASSACHUSETTS — Continued.

Normal Ground Waters — Concluded.

[Parts per 100,000.]

Alumina (Al_2O_3).	Silica (SiO_2).	Sulphuric Acid (SO_3).	Chlorine. Average.	Total Mineral Matter. Average.	Qualitative Tests.	
0.0173	0.89	0.131	0.26	2.73	- - -	1
0.0444	0.89	0.0	0.18	3.00	- - -	2
Large Population on Drainage Area — Concluded.						
0.0475	0.810	2.039	2.69	17.34	- - -	3
0.0325	1.140	1.536	2.80	20.25	- - -	4
0.0125	1.217	4.184	2.23	20.83	Lithium present.	5
Proximity of Sewage Fields — Concluded.						
0.0250	0.99	0.424	2.13	7.23	- - -	6

MINERAL ANALYSES OF WATERS IN MASSACHUSETTS — Concluded.

Good Natural Filtration from Polluted Stream.

[Parts per 100,000.]

		Lime (Ca O).	Magnesia (Mg O).	Oxide of Iron (Fe O).	Oxide of Manganese (Mn O).
1	Hyde Park, Neponset River,	1.493	0.589	0.0250	0.0674
2	Hyde Park, tubular wells, near river,	1.681	0.640	0.0167	0.0779
	Imperfect Natural Filtration from Polluted Stream.				
3	Hyde Park, starch factory well, near river,	1.040	0.261	.0635	0.0
	Good Natural Filtration from Polluted Pond.				
4	Woburn, Horn Pond,	1.831	0.456	.0178	0.0290
5	Woburn, filter-gallery,	2.300	0.663	.0000	0.0267
	Imperfect Natural Filtration from Unpolluted Reservoir.				
6	Wayland, reservoir,	0.596	0.163	0.0628	0.0196
7	Wayland, filter-gallery,	0.643	0.184	0.1820	0.0289
	Wells Containing Considerable Iron in Solution, as the Result of Organic Matter and Iron in the Ground.				
8	Westborough, insane hospital, tubular wells,	2.817	0.421	.1625	0.0730
9	Reading, filter-gallery,	1.893	0.539	.3020	0.0674
10	Bradford, Well No. 7,	1.120	0.290	.4420	0.0775
11	Bradford, Well No. 12,*	1.026	0.150	0.0	0.0231
	Wells Near the Sea.				
12	Marblehead Water Company, Swampscott, large wells and tubular wells.	8.510	3.860	.0096	0.0190
13	Marblehead, town supply, large well and tubular wells.	4.250	0.539	.0330	0.1250
	Sewage (Filtered through Filter Paper).				
14	Lawrence,	2.550	0.106	.5288	0.0814
	Effluents from Intermittent Filtration of Sewage at Lawrence.				
15	Tank 4,	3.443	0.992	.0135	0.7153
16	Tank 9,	2.371	0.617	.0470	0.3070

* Well No. 12 is situated some distance from the bank of the river, while well No. 7 is nearer the bank. The effect of the greater distance is seen in the absence of iron in well No. 12.

MINERAL ANALYSES OF WATERS IN MASSACHUSETTS — Concluded.

Good Natural Filtration from Polluted Stream — Concluded.

[Parts per 100,000.]

Alumina (Al_2O_3).	Silica (SiO_2).	Sulphuric Acid (SO_3).	Chlorine. Average.	Total Mineral Matter. Average.	Qualitative Tests.	
0.0062	1.130	1.755	1.90	10.45	- - -	1
0.0440	1.150	1.648	1.49	9.57	- - -	2
***Imperfect Natural Filtration from Polluted Stream* — Concluded.**						
0.0175	0.833	0.388	1.14	8.95	Lithium present. Potassium in considerable amount.	3
***Good Natural Filtration from Polluted Pond* — Concluded.**						
0.0409	0.770	0.653	1.76	6.84	- - -	4
0.0143	1.396	0.598	1.79	10.85	Lithium present.	5
***Imperfect Natural Filtration from Unpolluted Reservoir* — Concluded.**						
0.0360	0.430	0.196	0.20	2.16	- - -	6
0.0475	0.429	0.136	0.25	2.72	- - -	7
***Wells Containing Considerable Iron in Solution, as the Result of Organic Matter and Iron in the Ground* — Concluded.**						
0.0250	1.366	0.512	0.42	11.36	Lithium present. Potassium in considerable amount.	8
0.0493	1.956	5.960	0.43	12.96	Lithium present.	9
0.0250	1.133	0.707	0.21	7.20	Lithium present.	10
0.0100	0.782	0.374	0.42	6.80	Potassium in considerable amount.	11
***Wells Near the Sea* — Concluded.**						
0.0125	1.660	2.980	14.53	54.94	Lithium present.	12
0.0110	1.540	3.060	9.56	32.39	- - -	13
***Sewage (Filtered)* — Concluded.**						
0.3850	1.020	1.770	5.73	22.70	- - -	14
***Effluents from Intermittent Filtration of Sewage at Lawrence* — Concluded.**						
0.0266	1.030	1.858	6.64	17.30	- - -	15
0.0457	0.867	1.334	9.24	-	-	16

NOTES: — In the surface waters the iron is calculated as sesquioxide (Fe_2O_3); in the ground waters, sewage and effluents, as protoxide (FeO). The different averages for the chlorine and total mineral matter in the sewage effluents from the two tanks are probably due to the fact that in the regular practice at the Lawrence Experiment Station sewage is applied to each tank at a definite time of the day. The *average* composition of sewage, which is given in the table, would probably differ from that at any one time during the day.

Sanitary Analyses of the Above Waters — Average of Many Determinations.

[Parts per 100,000.]

	Color.	Ammonia.				Nitrogen as		Hardness.	Oxygen Consumed.
		Free.	Albuminoid.			Nitrates.	Nitrites.		
			Total.	Dissolved.	Sus-pended.				
Mansfield, well, ...	0.0	.0000	.0014	-	-	.0083	.0000	-	-
Framingham, spring north-east of sewage fields.	0.0	.0000	.0020	-	-	.0050	.0000	-	-
Stoughton, well, ...	0.0	.0013	.0040	-	-	.8280	.0040	5.1	-
Everett, spring, ...	0.0	.0000	.0018	-	-	1.0000	.0000	6.4	.0320
Malden, tubular wells, . . .	0.0	.0001	.0007	-	-	.5146	.0001	9.6	.0140
Framingham, spring north-west of sewage fields.	0.0	.0000	.0004	-	-	.5000	.0000	3.6	.0182
Hyde Park, Neponset River, .	0.9	.0260	.0324	.0286	.0038	.0090	.0012	4.4	.9464
Hyde Park, tubular wells, . .	0.03	.0005	.0057	-	-	.0532	.0002	3.9	.0160
Hyde Park, starch factory well, .	0.20	.0444	.0086	-	-	.0400	.0005	3.6	-
Woburn, Horn Pond, . . .	0.25	.0110	.0358	.0216	.0142	.0821	.0008	3.3	.3500
Woburn, filter-gallery, . . .	0.0	.0012	.0024	-	-	.0542	.0000	5.1	.0511
Wayland, reservoir, . . .	0.98	.0024	.0268	.0213	.0055	.0101	.0001	1.9	-
Wayland, filter-gallery, . . .	0.42	.0175	.0138	-	-	.0211	.0001	1.9	-
Westborough, insane hospital, .	0.08	.0487	.0047	-	-	.0038	.0000	6.0	.0847
Reading, filter-gallery, . . .	0.44	.0042	.0073	-	-	.0071	.0001	3.4	.3744
Bradford, Well No. 7, . . .	0.20	.0960	.0054	-	-	.0000	.0000	2.7	.2730
Bradford, Well No. 12, . . .	0.00	.0000	.0000	-	-	.1800	.0001	2.6	.0182
Marblehead Water Company, Swampscott, well and tubular wells.	0.00	.0000	.0010	-	-	.7437	.0000	22.0	.0252
Marblehead, town supply, well and tubular wells.	0.01	.0001	.0005	-	-	.1808	.0002	11.3	.0577
Lawrence, sewage (average of four years).	-	1.8591	.6644	.2943	.3701	.0000	.0000	-	3.4400
Lawrence, tank 4 effluent (average, June to December, 1891).	-	.0033	.0117	-	-	1.7600	.0002	-	.1500
Lawrence, tank 9 effluent (average, August to December, 1891).	-	.2095	.0241	-	-	1.4500	.0061	-	.2800

A study of the above tables shows very plainly the influence of a large population upon a drainage area on the mineral contents of its surface and ground waters. There are many instances of ground waters of high purity, regarded from the stand-point of organic contamination (as, for instance, the wells at Malden), which show by their mineral contents — the large amounts of lime, magnesia, chlorine and sulphuric acid — that the water had previously contained a large amount of sewage or house drainage. The influence of sewage

on the mineral contents of a ground water may be well observed by comparing the analysis of the natural spring at Framingham to the east of the sewage fields, which is unaffected by the sewage, with the spring on the west of the fields, which receives the effluent from the sewage after complete oxidation of the organic matter by thorough filtration. By subtracting from the amounts of the various mineral substances in the west spring the corresponding amounts in the east spring, the quantity of mineral matter contributed to the ground water by the sewage is at once apparent. It is as follows:—

[Parts per 100,000.]

	Lime.	Magnesia.	Silica.	Sulphuric Acid.	Chlorine.	Total Mineral Matter.
North-west spring, ...	1.3410	0.3320	0.9900	0.4240	2.13	7.23
North-east spring, ...	0.1430	0.0626	0.8900	0.0000	0.18	3.00
Mineral matter due to sewage, .	1.1980	0.2694	0.1000	0.4240	1.95	4.23

It will be noted that well filtered and purified ground waters contain little or no iron in solution. The effect of perfect filtration, through well-aerated ground, is to oxidize and retain the iron. When, however, the air supply in the ground is deficient, as when its filtering power is overtaxed, or the accumulation of organic matter becomes so great that the air capacity is diminished, then the sesquioxide of iron is reduced by the organic matter to the protoxide, and passes into solution, to be again precipitated when the water is exposed to the air. This is the condition of the wells at the Westborough Insane Hospital, at Reading, at Bradford and at Wayland. Iron in solution in a ground water indicates the presence of organic matter and iron oxide together in the ground, and the absence of free oxygen. Any considerable amount of iron in a water unfits it for domestic use, since the water becomes turbid and milky on exposure to the air, and ultimately deposits a rusty precipitate of iron oxide. This matter has been previously discussed in the article on the Interpretation of Analyses in this volume, and in the Twenty-third Annual Report (p. 66), in connection with the test wells at Attleborough.

Phosphoric acid, which is usually present in sewage, is seldom found to any appreciable extent in well-filtered waters, since it remains in the ground in combination with iron oxide and alumina.

A STUDY OF ODORS OBSERVED

IN THE

DRINKING WATERS

OF

MASSACHUSETTS.

By GARY N. CALKINS,

ASSISTANT BIOLOGIST OF THE BOARD.

A STUDY OF ODORS OBSERVED IN THE DRINKING WATERS OF MASSACHUSETTS.

By GARY N. CALKINS, Assistant Biologist of the Board.

One of the commonest sources of annoyance in the drinking waters of Massachusetts is the occurrence in them of more or less objectionable odors or tastes.

The lack of knowledge concerning the causes of these sources of annoyance, and ignorance of proper remedies, have made imperative a scientific examination of the subject. Much has been learned, and, although much still remains to be done, it has been considered best to bring together what has thus far been ascertained, in the hope that the results may be made available to others, and stimulate further inquiries.

Pure, fresh water is free from all objectionable odor or taste. Whatever, therefore, of this kind, a water may exhibit, is entirely foreign. As regards taste, it may be said that this is probably seldom offended by substances in water. The sense of taste, as is well known to physiologists, is limited in scope, and most so-called "tastes" are really odors. I shall, therefore, restrict this discussion to the subject of odors. In order that an odor shall be detected, it is necessary that some gas or vapor shall enter the nose, either through the nostrils or the posterior nares. Gases or vapors are held by cold water, but are given off when warmed, so that odorous waters are most objectionable when used for washing or cooking.

Few surface waters are wholly free from odor. Their odors, however, are usually too faint to be observed by the ordinary consumer. But when the odor of the drinking water becomes so strong that, in the words of a citizen, "It is so bad that I do not care to go through the kitchen on wash days," the people complain, and the State Board of Health is appealed to for aid.

Theoretically the odor of a water supply might be due to dissolved or suspended odoriferous materials of inorganic origin. But this probably seldom or never happens, because no such odorous substances are known to affect great bodies of water. There remains only the organic matter of which more or less exists in all surface waters. But the organic matter may be either living or lifeless; it may be, for example, peat upon the bottom of a reservoir or green "scums" on the surface; and there is good reason to believe that the ultimate cause of odors is the activity of living, rather than the presence of dead, organic matter, or, in other words, the metabolic activity of organisms either bacterial or microscopical.*

The late Wm. Ripley Nichols was among the first to seek, in the microscopic plants and animals of drinking waters, the causes of odors. Since his time there have been numerous references to the subject by others, among whom may be mentioned G. H. Parker, former biologist of the Board, T. M. Drown, chemist of the Board, G. W. Rafter of Rochester, N. Y., W. G. Farlow of Harvard University, F. F. Forbes of Brookline and J. D. Hyatt of New York. The work of most of these has been to associate a particular odor with a specific organism, and in few cases have they attempted to ascertain the causes of odors.

In the present paper I desire to give some of the results derived from my investigations as assistant biologist of the Board during the last two years,—results which in part corroborate the conclusions of others, and in part suggest new ideas which may serve some purpose in helping others to carry on the work, and in many cases to discover some practical means of remedying the evil. I desire at the outset to express my thanks to Dr. T. M. Drown and Mrs. Ellen H. Richards, chemists of the Board, for their kind assistance, and to Professor Sedgwick, biologist of the Board, whose encouragement and advice have been unfailing.

The Different Odors of Drinking Waters.

In the discussion of results which follows, it must be kept in mind that the microscopical organisms present are usually alive. There is reason to believe that if they die *en masse* other and more disagreeable odors may arise from their putrefaction. In connecting odors

* See Special Report of the Board on the Purification of Sewage and Water, 1890, Biological Work, page 797.

with organisms, therefore, it must be understood that the results here considered are obtained from the prompt examination of large samples quickly dispatched from the source to the laboratory. It is not meant to imply that a certain amount of death and destruction of the microscopical organisms may not be going on in natural waters, but only that the bulk of those organisms present must be regarded as alive.

As previously stated, absolutely pure drinking waters are free from odor, and we must look for some foreign cause in a water, normally odorless, which suddenly develops a disagreeable odor. This odor is usually found to be due to some one or more species of microscopical organisms, and, apparently, it may result (1) from the excretion of certain body products, (2) from the liberation of certain internal substances, or (3) from the bacterial decomposition of their dead bodies.

If a water free from organisms and odors suddenly develops a peculiar odor, and if microscopical examination shows that only one species of organism is present, we may infer that the odor is due to that organism. If the same odor occurs again in perhaps some different supply, and if the same organism is present, we have corroborative evidence of our inference. The more instances that we have of this concomitance of specific organisms and certain odors, the more sure we are of their relation as cause and effect. The further proof of this relationship comes, when, in filtering out these organisms and in transferring them to pure, odorless water, they impart to that water the characteristic odor. In this way it has come to pass that certain microscopic forms have been identified as the causes of certain odors, each of these odors being well known to the specialist and easily recognized by him.

The method in use for ascertaining the numbers and varieties of micro-organisms in drinking waters has been fully described in a previous report of the Board.* It consists of the filtration of a known volume of water, concentration of the organisms thus obtained in a known quantity of freshly distilled water, and examination and enumeration of the organisms in a known portion of this distilled water containing the concentrated organisms, which is collected in a cell of fixed and known dimensions. But it not in-

* G. N. Calkins, "The Microscopical Examination of Drinking Waters," Twenty-third Annual Report of the State Board of Health of Massachusetts, for the year 1891, page 397.

frequently happens that certain organisms are too delicate to resist even the slight pressure of concentration by this method, and their enumeration must be made directly from the bottles. The phenomenon of diffluence also, is especially significant, and in many cases it apparently bears a direct relation to the odor-producing power of the organisms.

In the regular work of the Board the odors of waters are observed and recorded when they first arrive at the laboratory. The bottle is first shaken violently, the stopper is then removed and the nose is quickly placed over the mouth of the bottle. In this way the gases, which are diffused throughout the water, having been partially liberated, odors can be obtained which would not be noticeable in the same water poured into a vessel. The result of this determination is called the "cold odor." Upon heating a portion of the water, odors are sometimes obtained which were not observed in the same water when cold, and the odor frequently persists until apparently any organisms contained in the water are entirely broken up. The practice in observing the hot odor is to place a 500 cubic centimeter covered beaker, containing about 200 cubic centimeters of water, upon a heated iron plate until the air bubbles have all been driven off and the water is about to boil. The beaker is then taken from the plate and allowed to cool for about five minutes, after which the water is agitated by a rotary motion, and then the nose is placed inside the beaker. This must be done quickly, for the hot odor lasts but a moment.

By examinations made in this way, and often repeated, the experts of the Board have come to recognize certain well-defined odors which have been named according to the impressions which they convey. The principal odors are *vegetable*, *sweetish*, *aromatic*, *grassy*, *mouldy*, *fishy*, *disagreeable*, *offensive*, *musty*, and *earthy*. To all of these adverbs may be applied denoting greater or less strength, such as faintly, distinctly, decidedly, etc.

There is often difficulty in defining an odor, or giving it a name that shall definitely suggest or describe it to others. Each observer will naturally define his sensation by comparing it with something of which it reminds him. But the next observer may not agree with this definition, and definitions, therefore, must be made only with the utmost hesitation and circumspection.

In the work of the Board the following definitions, if such they may be called, have been gradually adopted for the several odors named above :

there were at first attempts to distinguish certain odors in natural waters as *straw-like*, *peaty*, *swamp-like*, etc., but it was found that no two observers agreed in regard to them; that which would seem *marshy* to one might be *straw-like* to another and perhaps *peaty* to a third. For the sake of conformity, therefore, these and similar odors have been grouped into one general class, to which has been given the name *vegetable*. The terms *mouldy* and *musty* have been used to denote certain odors which are well defined and different from all others, yet giving to a certain extent a similar sensation. The former is used to denote a sensation very similar to that which one ordinarily experiences upon entering a close, damp room which has been deprived of sunlight, as for example, a cellar or vault. The term *musty* is usually employed to express the odor peculiar to waters contaminated by sewage. The odor termed *disagreeable* is usually associated with waters in which there is considerable decomposition of vegetable matter. *Offensive* is used to designate the odors of waters in which there is a considerable amount of decomposition of animal matter; and the term *unpleasant* is used for waters in which there is a large amount of either vegetable or animal matter, yet without decomposition. The term *grassy* is employed to describe a certain odor observed in waters which contain great quantities of live vegetable matter. The sensation which it excites resembles that arising from freshly cut grass. Another class of odors is covered by the term *fishy*. The *fishy* odor, when present in water, is usually very distinct, and suggestive of the seashore. It may remind one of salt marshes, of seaweed, of fish, or even of Irish moss, but it invariably suggests something connected with the sea. Still another group of odors is denoted by the term *aromatic*, the most familiar example of which is the fragrant odor which has been called *geranium*, because of its strong resemblance to the odor of that plant.

The records of the chemical and biological work of the Board furnish an abundance of material for a statistical study of these odors, from which we may get an idea of the association of specific odors with certain classes of organisms. From our records, also, it is possible to trace the specific organisms which have been found most frequently in such odor-giving waters.

The following table shows the results of such a statistical study of the records. The organisms are grouped in classes which were adopted several years ago, and which we have left unchanged: —

TABLE I. — *Odors and Organisms.*

	Vegetable.	Sweetish.	Aromatic.	Grassy.	Mouldy.	Fishy.	Disagree-able.	Offensive.	No Odor.	Total.
Diatoms,	58	5	32	17	14	3	19	-	26	174
Diatoms and Cyanophyceæ,	3	1	2	12	1	0	3	-	1	23
Diatoms and Algæ,	8	1	1	5	2	0	2	-	2	21
Diatoms and Infusoria,	14	0	3	5	1	2	2	-	0	27
Diatoms and Fungi,*	41	4	7	15	14	0	8	-	11	100
Cyanophyceæ,	12	0	1	49	12	1	7	-	3	85
Cyanophyceæ and Algæ,	1	0	0	5	0	0	0	-	0	6
Cyanophyceæ and Infusoria,	1	0	0	1	0	0	1	-	0	3
Cyanophyceæ and Fungi,*	1	1	0	9	3	0	3	-	1	18
Algæ,	6	3	3	5	2	1	3	-	2	25
Algæ and Infusoria,	4	0	0	1	0	0	1	-	1	7
Algæ and Fungi,*	4	0	1	2	3	0	1	-	0	11
Infusoria,	15	2	7	1	3	34	15	-	2	79
Infusoria and Fungi,	13	0	0	0	8	0	2	-	2	25
Fungi,*	70	10	6	6	43	0	5	100	46	286
Mixture,	46	5	5	28	20	3	11	-	12	130
No Organisms,	63	66	16	41	20	3	9	-	166	384
Total,	360	98	84	202	146	47	92	100	275	1,404

* Including Zoöglœa.

The determinations in this table represent 1,404 different samples of waters from reservoirs, lakes, ponds, rivers and brooks. They are all common surface waters or ground waters stored in open reservoirs, and, with the exception of the class of waters under the heading offensive, they are all comparatively free from sewage contamination. I have purposely left out of consideration waters from springs, taps and filter-galleries, because such waters are abnormal in regard to the organisms contained.

These 1,404 samples may be divided according to the organisms in them, as follows: —

174 waters, or 12 per cent., contained diatoms only.
171 " 11 " " diatoms with other organisms.
85 " 6 " " cyanophyceæ only.
50 " 3 " " cyanophyceæ with other organisms.
25 " 2 " " algæ only.

45 waters,	or 3	per cent.,	contained	algæ with other organisms.
79	"	5	"	"	infusoria only.
62	"	4	"	"	infusoria with other organisms.
286	"	19	"	"	fungi only.
154	"	11	"	"	fungi with other organisms.
130	"	9	"	"	a mixture of several classes.
384	"	26	"	"	no organisms.

From these tables we may get, in the first place, an idea of the usual occurrence of organisms in drinking waters. For example, from them we learn that in about one-fourth of all waters observed there are no organisms in abundance.

We also find that the most common forms of microscopical organisms are diatoms and fungi. The large number of these forms is explained by the fact that they occur at all seasons of the year, while the cyanophyceæ and algæ occur only at certain times.*

A. *No Organisms and Odors.*

Three hundred and eighty-four waters, or about 26 per cent. of all cases, contained no organisms. The odors of these waters are distributed as follows: —

166, or 43	per cent.,	had	no odor.
66, or 17	"	"	a sweetish odor.
63, or 16	"	"	a vegetable odor.
41, or 11	"	"	a grassy odor.
20, or 5	"	"	a mouldy odor.
16, or 4	"	"	an aromatic odor.
9, or 2	"	"	a disagreeable odor.
3, or 1	"	"	a fishy odor.

From this table it appears that, in a large percentage of the waters with which we have to deal, no organisms means no odor. The exceptions to this rule, however, still require close study. Two hundred and eighteen waters which contained no organisms had an odor of some sort; but in some of these a satisfactory explanation is found in a consideration of the specific causes of the odors. For example, 66 of the waters in this group had the *sweetish* odor. Now this is due, as will be shown later, to certain substances dissolved from leaves and other vegetable matter which have fallen into the water and are never observed in the microscopical exami-

* Seasonal Distribution of Organisms, see page 381 of this report.

nation. The origin of the vegetable odor observed in 63 of these waters is not known, but may be perhaps explained by the presence in the source of filamentous algæ, of water reeds and grasses, which likewise are never found under the microscope. Then too, many samples of water sent in bottles for examination probably do not contain a good representation of the microscopical organisms in the source from which they came. The odor of such waters may perhaps be attributed to forms of vegetable life attached to the bottoms and sides of lakes, reservoirs and ponds, or floating in conspicuous masses which are avoided by the collector.

B. *Diatoms and Odors.*

The relationship between the diatoms and the various odors may be perceived from the following tabulation of the 174 waters containing diatoms: —

58, or 33	per cent.,	had	a vegetable odor.
32, or 18	"	"	an aromatic odor.
26, or 15	"	"	no odor.
19, or 11	"	"	a disagreeable odor.
17, or 10	"	"	a grassy odor.
14, or 8	"	"	a mouldy odor.
5, or 3	"	"	a sweetish odor.
3, or 2	"	"	a fishy odor.

From this it would appear that the most frequent odor found in connection with the diatoms as a class is the *vegetable*, and that, in 33 waters out of 100 which contain diatoms, we should expect to find this odor. In about 18 out of the 100 waters we should expect to find an *aromatic* odor, and in 15 waters we might find no odor. We shall see in a later section, however, that the odor apparently depends upon the genus of diatoms present. Some genera may be present in great abundance (*Synedra* and *Melosira*, for example), and yet no odor will be observed; whereas in other cases, with certain different genera occurring perhaps in less abundance, a characteristic odor almost invariably exists.

We find the same results with combinations of diatoms and other organisms, especially the diatom-fungi combination, of which 41 per cent. give the *vegetable* odor, and the diatom-infusoria combination, of which over 50 per cent. give the same odor (see Table I.). The large percentage of the *grassy* odor (52 per cent.) in the case of

a mixture of cyanophyceæ and diatoms is fully explained by the preponderance of the characteristic odor of certain of the cyanophyceæ.

C. *Cyanophyceæ and Odors.*

In the group cyanophyceæ we have one of the clearest examples of the direct connection of odors and organisms. The relations of this class of organisms to odors can be best shown by the following summary of the 85 waters containing cyanophyceæ: —

49, or 58	per cent.,	had a grassy odor.
12, or 14	"	" a vegetable odor.
12, or 14	"	" a mouldy odor.
7, or 8	"	" a disagreeable odor.
3, or 4	"	" no odor.
1, or 1	"	" a fishy odor.
1, or 1	"	" an aromatic odor.

This table shows plainly that the *grassy* odor is most often present in waters containing cyanophyceæ in abundance.

The same results are shown by combinations of the cyanophyceæ and other organisms. For example, of the 23 waters containing diatoms and cyanophyceæ (see Table I.), 12, or 52 per cent., have the *grassy* odor; 5 out of 6 cases in which cyanophyceæ and algæ are present give the same odor; and the same is true of 50 per cent. of all waters containing a mixture of cyanophyceæ and fungi.

D. *Algæ and Odors.*

Our records furnish only a small number of instances in which the algæ have been the only organisms in abundance. In these cases the distribution is as follows: —

6, or 25	per cent.,	had a vegetable odor.
5, or 20	"	" a grassy odor.
3, or 12	"	" a sweetish odor.
3, or 12	"	" an aromatic odor.
2, or 8	"	" a mouldy odor.
2, or 8	"	" no odor.
1, or 4	"	" a fishy odor.

The small number of cases makes the conclusions drawn from this summary of little value, as it is possible that the filamentous forms growing on the bottoms and sides of ponds and reservoirs may have much more effect upon the odor of waters than do the suspended forms.

E. *Infusoria and Odors.*

The distribution of infusoria according to the various odors can be seen in the following tabulation of the 79 waters containing infusoria: —

34, or 43	per cent.,	had	a fishy odor.
15, or 18	"	"	a disagreeable odor.
15, or 18	"	"	a vegetable odor.
7, or 9	"	"	an aromatic odor.
3, or 4	"	"	a mouldy odor.
2, or 3	"	"	no odor.
1, or 1	"	"	a grassy odor.

In this group we have a good illustration of the relationship between organisms and odors. Here, too, we have been unusually successful in connecting specific organisms with specific odors. Forty-three per cent. of all waters containing infusoria give the *fishy* odor, although it is very probable that the different species are not equally capable of producing odors.

F. *Fungi and Odors.*

The following summary of the 386 waters containing nothing but fungi (Zoöglœa is included here with fungi) shows the different odors to be more evenly distributed: —

100, or 35	per cent.,	had	an offensive odor.
70, or 24	"	"	a vegetable odor.
45, or 16	"	"	no odor.
43, or 15	"	"	a mouldy, musty odor.
10, or 4	"	"	a sweetish odor.
6, or 2	"	"	a grassy odor.
5, or 2	"	"	a disagreeable odor.

The 100 waters giving the *offensive* odor are abnormal waters (sewage polluted), in which Zoöglœa is invariably present in abundance; but there are other substances present in such waters besides the fungi, and to these other substances the odor is due. This table, therefore, seems to show that no particular odor is caused by the fungi in water.

G. *Various Organisms and Odors.*

One of the most interesting features of Table I. is shown in those samples which contain a mixture of the different classes of organisms. Of course in these waters we should expect an indication of that odor characteristic of the class of organisms which is in excess. If certain infusoria were in excess we might expect a *fishy* odor, if diatoms and algæ, a *vegetable* odor, and if cyano-

phyceæ, a *grassy* odor, according to the above several summaries. The distribution of these 130 waters containing various organisms according to the odors which are connected with them is given in the following summary: —

46, or 33	per cent.,	had	a vegetable odor.
28, or 22	"	"	a grassy odor.
20, or 15	"	"	a mouldy odor.
12, or 9	"	"	no odor.
11, or 8	"	"	a disagreeable odor.
5, or 4	"	"	a sweet odor.
5, or 4	"	"	an aromatic odor.
3, or 2	"	"	a fishy odor.

Various Odors in Relation to Different Organisms.

Approaching the subject from the stand-point of odors instead of organisms, we may obtain a few additional facts.

In the first place, we notice that the odors are well distributed. The *vegetable* odor, as might be expected, is the most common, 26 per cent. of all cases giving this odor. The other odors are: *grassy*, 14 per cent.; *mouldy*, 10 per cent.; *offensive*, 7 per cent.; *disagreeable*, 6 per cent.; *aromatic*, 6 per cent.; *sweetish*, 6 per cent.; and *fishy*, 3 per cent.; 20 per cent. of all waters had no odor.

The table shows that there are 360 waters in which the vegetable odor was recorded. Since every group of organisms is represented in this column of Table I., it is impossible to claim that this odor is due to any one of them, because, while in one set of samples diatoms, for example, may be most abundant, in another set some other organism may be present in equal numbers and give the same odor. It is interesting to note, however, the distribution of the several classes of organisms in the 360 waters according to this odor: —

Vegetable Odor.

16	per cent.	contained	diatoms only.
11	"	"	diatoms and fungi.
4	"	"	diatoms and infusoria.
2	"	"	diatoms and algæ.
1	"	"	diatoms and cyanophyceæ.
3	"	"	cyanophyceæ only.
1	"	"	cyanophyceæ and others.
2	"	"	algæ only.
2	"	"	algæ and others.
4	"	"	infusoria only.
3	"	"	infusoria and others.
19	"	"	fungi only.
13	"	"	various organisms.
18	"	"	no organisms.

Again, the figures in Table I., under the heading *sweetish*, show very clearly that no particular class of organisms can be selected as the cause of this odor. Indeed, in the 98 waters in which the *sweetish* odor was recorded, 67 per cent. contained no organisms. But there is one fact in regard to this odor that must not be overlooked, namely, that in almost every case in which the *sweetish* odor is reported the water was colored brown.* Experiments in the laboratory have shown that the color of brown water is due to the presence in solution of certain glucosides, of which tannin is a typical example. While these substances give color to the water, they also give rise to the odor which has been denoted by the term *sweetish*. It is of true vegetable origin, however, for the tannin and other glucosides are but constituents of vegetable substances, such as leaves, and thus the theory is sustained that the odors of waters are due to the presence of organic matter. This can be shown by allowing a leaf to remain in perfectly clear water for some time. The leaf at length becomes a mere skeleton, while the water in which it lies gradually becomes brown, and the peculiar *sweetish* odor becomes more and more noticeable. A similar thing is shown by the odor and taste imparted to water by tea leaves.

Of the 84 cases of the occurrence of aromatic odors, 38 per cent. contained diatoms only, 19 per cent. contained no organisms, 15 per cent. contained a mixture of diatoms and some other form, 8 per cent. contained infusoria, and 6 per cent. contained a mixture of all forms. It should be noticed that the cyanophyceæ are not represented in this group. The great excess of diatoms over all other forms of organisms in these cases indicates that diatoms, above everything else, have the capacity of producing this peculiar odor. It has also been shown that waters can contain great numbers of certain diatoms and yet give no odor, while other genera appear to give rise to a particular *aromatic* odor, which is very strong and easily recognized in the cases of *Asterionella* and *Tabellaria*. In our records there are 32 waters which had the *aromatic* odor and contained nothing but diatoms, and 24 of these, or 75 per cent., contained only *Asterionella* or *Tabellaria*. A few of these waters contained as many as 25,000 individuals in 1 cubic centimeter, and in such cases the relation between odor and organisms could not be mistaken. It is possible, and indeed highly probable,

* T. M. Drown, on Odor and Color of Surface Waters. Journal of the New England Water Works Association, March, 1888.

that other forms of diatoms may produce the same or some allied odor, provided they occur in sufficient numbers. *Meridion circulare*, for example, has been alleged to produce such an odor.* On the other hand, some species of diatoms are found in great abundance without imparting to the water any particular odor. *Synedra* and *Melosira*, for example, have frequently been found in numbers twice as great as would be necessary to produce an odor were the organisms *Asterionella* or *Tabellaria*. It is not a question of size, for *Synedra* and *Melosira* are quite as large, bulk for bulk, as *Asterionella*. From our records we cannot attribute the *aromatic* odor to any form of organisms other than the diatoms, for in 53 per cent. of all waters having the *aromatic* odor, diatoms alone were present in abundance.

One group of organisms, the cyanophyceæ, seems to be especially connected with the *grassy* odor, for in 59 per cent. of all waters having this odor, cyanophyceæ were present in great abundance. We can further differentiate the odor, and locate the specific organisms which give the most trouble in this respect. Of 76 waters having the *grassy* odor and containing cyanophyceæ, 53 waters contained *Anabæna* or some other forms of Nostocaceæ. *Cœlosphærium* and *Clathrocystis* do not seem to give this odor, for I have been unable to find a case where these two forms were present in abundance, and in which the *grassy* odor was recorded.

While the above facts appear to prove conclusively that *Anabæna* is one cause of the *grassy* odor in water, we have, on the other hand, no ground for assuming that it, or indeed the cyanophyceæ in general, are the only forms capable of producing it. Indeed, we have already seen that 20 per cent. of the 202 waters in which the *grassy* odor was recorded contained no organisms, while the cyanophyceæ were present in only 41 per cent. Still, in the waters as they come to us in bottles, the *grassy* odor is invariably noticed when certain cyanophyceæ are present, and disappears when the latter are no longer seen; so that we are justified in claiming that some, at least, of the cyanophyceæ produce this odor.

Table I. cannot help us in finding the cause of the *mouldy* odor, for, although the fungi are present in 30 per cent. of all waters having this odor, this signifies nothing, as the table shows that the

* J. D. Hyatt, on Sporadic Growth of Certain Diatoms. Transactions of the American Society of Microscopy, 1882, p. 197.

fungi are even more abundant in waters having no odor or having the *vegetable* odor. As a matter of fact, the experts of the Board have been able to differentiate the *mouldy* odor into *musty* and *mouldy* odors. The latter of these is reported in waters containing cyanophyceæ (8 per cent. in Table I.), while the former is reported in waters containing either fungi or no organisms at all. Moreover, a glance at the history of the waters having the *musty* odor usually shows sewage pollution.

The *fishy* odors are quite distinct, and many of these we have succeeded in tracing to specific causes. Of the 47 waters having this odor, 34, or 72 per cent., contained infusoria, while 11 per cent. contained a mixture of infusoria and other organisms; this leaves about 17 per cent. in which some other condition prevailed, of which one-third was reported as having no organisms. On the other hand, of all the waters containing infusoria, about 50 per cent. had the *fishy* odor, while about 25 per cent. had a disagreeable odor, which might readily be aggravated cases of the *fishy* odor.

While there is every reason to believe that the infusoria alone of all classes of organisms give the *fishy* or *sea-shore* odor, we cannot by any means affirm that all infusoria give this odor, because the facts at our command are not sufficient for such a broad assumption. It is indeed probable that some forms do not give an odor, for I have frequently found *Peridinium* and *Trachelomonas* in great abundance, without observing any distinct odor.

The *fishy* odor is by no means always the same, and here we have more and greater variations, probably, than in any other class. Each genus of odor-giving infusoria seems to have its peculiar odor. The best-known instance of this is the case of *Uroglena Americana* (see Twenty-third Annual Report, State Board of Health, p. 647), with which we have had much experience during the last two years. This odor is so distinctly peculiar that we have repeatedly located the organism by merely observing the odor of the water. It is like the odor of fresh fish, not of dead ones, for people who complain of odors as "due to dead fish in the pipes" forget that the odor is that of fresh, live fish. *Cryptomonas* is another form of infusoria the odor of which we have been able to differentiate from all others; it is a sweetish, peculiar odor, very similar, when the organisms are alive and in a healthy condition, to the odor of candied violets. A new species of *Bursaria*, observed by me for the first time last winter, gives the well-marked odor of Irish moss, or a *salt-marsh*

odor. *Dinobryon* has been alleged to give a characteristic odor, as have also *Synura* * and *Volvox Globator*.†

From Table I. it will be seen that there were 3 waters which contained the *fishy* odor, but in which there were no organisms. That this condition may often occur is obvious from a consideration of the causes of these odors, which I shall present in a following section.

From what has now been shown, I think it safe to conclude that the odors of drinking waters often stand in certain definite relations to the organisms contained in them. This conclusion is strengthened by the fact that in the 1,404 waters examined only 275, or about 20 per cent., had no odor, and of these 275, 166, or 60 per cent., contained no organisms. For the 109 waters remaining which had no odor and yet contained organisms we must seek some explanation. Of these 109, 26 contained only diatoms, 14 contained a mixture of diatoms and some other form, 46 contained fungi only, 12 contained a mixture of all organisms, and the rest contained infusoria, algæ and other forms.

It is of course possible that the same organism may exist in waters under different conditions. Dead diatoms, for example, are frequently counted and recorded when nothing is present save the shell, and the effect of these shells upon the water obviously cannot be the same as of the same number of live organisms. The fungi probably give no odor, for I have found *Crenothrix* as abundant as 50,000 units per cubic centimeter, while the water had no odor. Here also there is a chance for misinterpretation, for the empty *Crenothrix* sheaths are counted like the live *Crenothrix* filaments, and they are obviously different. In two cases in which no odor was observed, infusoria were very abundant. This may have been due to either of two causes or to both. Either the organisms were not of a kind to give an odor (*Dinobryon cases*, *Peridinium*, *Trachelomonas*, for example), or else they were not in condition for the production of odors.

Again, while some odors seem to be connected with certain classes of organisms, others are not connected with any particular forms. Thus the vegetable odor cannot be traced to any one class of organisms. From Table I. it is seen that any class may be associated

* F. F. Forbes, The Relative Taste and Odor imparted to Water by Some Algæ and Infusoria. Journal New England Water Works Association, December, 1891.

† G. W. Rafter, Cause of the Odor and Taste in the Hemlock Lake Water Supply. Twelfth Annual Report of the City of Rochester, Rochester, N. Y.

with it, and it was observed even in 63 waters in which no organisms were found. Here we must look for some other cause than suspended organisms. It may be that the odor in such cases is due to the presence in the water of attached forms of filamentous algæ, or higher plants, which are not contained in samples of water sent to the laboratory. That filamentous algæ do possess an odor, may be readily ascertained by any one who will collect a handful of *Spirogyra*, *Ulothrix*, *Draparnaldia* or *Batrachospernum*, and smell of it. The odor thus obtained will be the same as the odor usually recorded as *vegetable*, although much stronger.

Origin of Odors in Specific Organisms.

This is essentially the question of the origin and liberation of odoriferous substances in the microscopical organisms. It cannot be wholly understood in the present state of our knowledge. Some progress, nevertheless, has been made, and the following discussion of the subject is intended to stimulate further inquiries.

The odors with which we are dealing are not of equal importance, and some of them can be briefly dismissed. The *vegetable* odor, for example, which is by far the most common odor in drinking waters, is probably due to the mere presence of organisms, some of which may be decomposed or decomposing, while others are alive. The direct cause of this odor I am unable to give from the data at hand, and the only attempt at an explanation that I have ever seen is that made by Mr. Rafter, who holds that the odor is caused by decomposing starch grains contained in the cells. The ultimate source of the *mouldy* odor, too, has never been found. On the other hand, the *offensive* odor is undoubtedly due to the presence of dead animal matter, or the waste products of animals such as we find in sewage or in sewage-polluted waters undergoing putrefaction. The *sweetish* odor, as shown, is due to the presence of tannin or the coloring material of brown waters, and this comes chiefly from decaying leaves which have fallen into the water.

The three remaining classes of odors give by far the most trouble in drinking waters, and of these the *grassy* odor seems to be the least understood. Thus far we have been unable to assign to it any specific cause. The other two classes of odors, the *aromatic* and *fishy*, are perhaps the most troublesome of all, but at the same time they are, fortunately, the best understood, so far as the specific cause

is concerned. They comprise only about 9 per cent. of the odors in our table, yet they are the most noticeable and the most objectionable; and whenever one of these odors appears in a water supply, it is almost sure to be followed by loud complaints from the consumers. In my work for the Board during the last two years I have had ample opportunity to study these forms, and the conclusions which I shall make are not drawn from any special investigation on the subject of odors, but from my general experience during this entire period.

Two general classes of odors only have hitherto been distinguished, namely, — those produced by the presence of the living animal or plant, and those produced during its decomposition or decay. To these two classes I have been able to add a third, namely, odors produced by disintegration; for while it is probable that certain organisms can impart an odor to a water supply by simple excretion, I have also found that other organisms produce an odor in a water supply by the liberation of certain of their body products by reason of the disintegration of their live bodies. It has been held that the odors in waters are due either to dissolved gases, which would give rise to odors observed when the water is cold, or to the bodies of organisms which are suspended in the water, which would give rise to odors observed when the water is either hot or cold. It has also been held that, if the bodies of the organisms are present in the water, the odor would continue after constant boiling until the bodies were entirely broken up; but if the bodies of the organisms were absent or filtered out, the odor would be quickly driven off.

A sample of water arrived in the laboratory in March, 1892, in which no organisms were found to account for the odor observed. To satisfy myself I undertook a series of experiments, to see if it is not possible that certain animals or plants can give rise to odors in waters, which cannot be driven off. For the successful conclusion of these experiments I am indebted to the aid of Miss I. F. Hyams. We put to soak for several days in separate bottles of distilled water the following substances: geranium leaves, onions, herring and cinnamon. After the distilled water had become thoroughly impregnated with these different substances, so that the odor in each case was easily detected by placing the nose over the mouth of the bottle, portions were filtered to remove all traces of solid matter, corresponding to the bodies of the organisms. The filtrates were

then heated and the odors taken at the point of boiling, and again after boiling five minutes, twenty minutes and one hour. The odor imparted to the water by the geranium leaf had disappeared at the end of twenty minutes. The onion odor became more and more faint, until at the end of the hour it was about half as strong as when first noted. The odors of the herring and the cinnamon became stronger and stronger, until at the end of the hour they were much more noticeable than at the beginning. The natural conclusion to be drawn from these experiments is that the odors of the waters containing onion, herring and cinnamon were due to the suspension of certain products, probably oil-like, which could not be filtered out, and that in the last two cases these were comparatively non-volatile at the boiling temperature, so that with the evaporation of the water the odor-giving substances were concentrated in a smaller bulk.

From these results I was led to suspect that, in addition to the odors due to gases or products of growth of organisms and to the decomposition of their dead bodies, there are odors due to the disintegration of the live bodies of the organisms and liberation of the odoriferous substances before decay sets in.

It has already been shown that the infusoria are responsible for the *fishy* odor in waters. Our most frequent and most noticeable example of this odor has been in connection with *Uroglena*, a genus of infusoria which has infested several of the drinking waters of Massachusetts during the last two years.

It is *Uroglena Americana*, in particular, which gives the distinct and characteristic odor, while *Uroglena radiata* and *Uroglena volvox* do not seem to affect the water to the same extent. The peculiarity of this odor is sufficient to prove the presence of *Uroglena Americana* without further examination.

The structure of *Uroglena Americana* has been fully explained in a previous report, and it has been shown that it contains, besides amylaceous products, nucleus and chromatophore plates, various-sized globules of oil, which in several cases were seen to exude from the disintegrated organisms, and which were more or less numerous in each cell.

The odor of *Uroglena Americana* is plainly not an odor of growth. That is, in the normal live condition of the organism there are no products of growth which give rise to a peculiar and characteristic odor in the water. This is proved by the fact that in freshly col-

lected samples of *Uroglena*-infested waters there is no indication of this odor; neither is there any taste to the fresh water if it be swallowed quickly, but if it be allowed to remain in the mouth for a short time the taste becomes disagreeably strong. The odor and taste develop, however, after the water has stood for some little time in a warm room, and occurs in samples coming from the same source of supply, but drawn from a tap at some distance from the source, the odor characteristic in such cases being quite intense, although *no Uroglena are present.*

Neither is the odor of *Uroglena Americana* due to putrefaction or decomposition, as is shown by corresponding bacterial and chemical examinations. In the examination of one *Uroglena*-infested water supply the number of bacteria was about the same in samples taken from all parts of the service, showing that decay was equally advanced throughout. In no case, however, were the bacteria present in sufficient numbers to warrant the assumption that unusual decomposition was going on, — 52 per cubic centimeter being the greatest number of bacteria found in any one sample. If the odor of *Uroglena* were due to putrefaction, we should expect it to be strongest where the number of bacteria is greatest. This was not the case here, however, for the greatest number of bacteria (52) was found in the sample taken directly from the pond, and which had no odor at the time of collection; whereas, in a sample collected from the tap, the odor was distinctly *fishy* while the bacteria were present to the number of only 18 per cubic centimeter. Again, the development of the taste upon allowing the water to stand a short time in the mouth is contrary to the idea that it is caused by putrefaction.

Finally, the odor of *Uroglena Americana* is distinctly oily or fishy, and very suggestive of fish-oil. Observing the abundance of oil-globules in each organism an attempt was made to concentrate a great number of colonies of *Uroglena*, and to find out the nature of this oil. Several millions of colonies were concentrated, and treated with gasoline and ether. Upon evaporation of these, the watch glasses were coated with a distinct oil-like substance, which gave off the characteristic odor of *Uroglena* greatly intensified. I have also obtained the same result by allowing water containing a great number of individuals to evaporate in a watch glass. The oil obtained from *Uroglena Americana* was found to be non-volatile at 100 degrees Centigrade.

From the foregoing facts I believe that the odor of *Uroglena Americana* can be explained only on the theory that it is an odor of disintegration, and that its direct cause is the liberation of the contained oil-globules.

It may not be out of place here to suggest how this disintegration may liberate the oil. A colony of *Uroglena Americana* at first breaks up by dissolution of the gelatinous matrix. The individuals are thus liberated, and exist for a short time free; but soon they too begin to disintegrate, the oil-globules of the interior exude and collect around the periphery of the individuals, from which they gradually break away and become distributed in the water (see plate, Fig. 3). This process I have watched in many cases, and a similar one with other forms of infusoria. In all such cases the organisms were alive until pressure of the coverslip or something else caused them to disintegrate and liberate the enclosed body products. In the case of *Uroglena* this process takes place during the passage of the water in a water supply from the reservoir or pond to the pipes. I have examined samples of water at the inlets to pipes leading to the pumps at Norwood and Plymouth, and samples drawn from taps at the engine houses after they had passed through the pumps. At the inlets *Uroglena* was present in great abundance, and the yellowish-brown spheroids could easily be seen with the naked eye. These samples gave no odor. After the water had passed through the pumps there were no colonies visible to the naked eye, but the odor was very distinct and strong. Also in samples collected from various taps I found the same results, — a distinct odor, and no organisms. Microscopical examination failed in many cases to reveal even the separated monads.

The phenomenon of disintegration may explain why we often find samples having a strong odor but containing no organisms.

Attempts have been made to find out the reason for the disintegration of the original colonies, but as yet we have not been successful. It was thought at first that the pressure of the pumps might be sufficient to disintegrate the jelly; but in Plymouth the same results were observed where the *Uroglena* entered the pipes directly, without first passing through the pump. It was then suggested that pressure in the mains might be the cause; but several experiments were made, in which live colonies of *Uroglena* were subjected to the pressure of the Boston mains, and the colonies remained uninjured.

Uroglena Americana is not the only species of mastigophora capable of liberating an oil, and of thus causing an odor in drinking waters. There is strong reason to believe that the different *fishy* odors and the *aromatic* odors of drinking waters are all due to the presence of some essential oils or resinous substances, which become liberated, and either dissolve in the water or remain suspended as globules. It seems only reasonable to account for the odors given by microscopical plants and animals, in the same way that we account for the odors of higher plants and animals. The geranium, for example, holds minute cells upon the surface of its leaves; each of these cells contains a globule of volatile oil, and when the cells are ruptured by contact with the hand or some foreign body, the oil drops are liberated, giving us the characteristic odor of geranium. So it may readily be with the diffluent protozoa which contain oil-globules. Their cells, which become ruptured by the disintegration of the body membrane, liberate drops of oil, and when the organisms are sufficiently abundant these give rise to an odor.

Another well-defined *fishy* odor has been traced to *Bursaria gastris* (n. sp.) (see plate, Fig. 1). This infusorian is probably a new species differing from the present species *Bursaria* (see Bütschli, Protozoa, in Bronn's *Klassen und Ordnungen des Thierreichs*, Vol. III.) in having a small oval macronucleus instead of the long band-formed macronucleus of the original species *Bursaria*. In the transparent body of this organism one can easily see, besides the large incepted food particles, nucleus and vacuoles, from one to four or more oil-globules in each individual. The cell walls are of delicate gelatinous structure, and the process of disruption of the individual is very characteristic. If a fresh live specimen is placed under a cover glass its movements soon become uncertain, and it begins to disintegrate. This takes place by a loosening of the membrane, which shakes like the sides of an empty sack. Pieces are soon broken off, at first from the upper ciliated margins and then continuing down until the peristome is reached. After this the entire organism becomes an amorphous mass, although frequently still moving while in this condition by reason of the œsophageal membrane. The contents of the body are liberated by this diffluence, and among them the oil-globules. This organism has not been widely distributed in the drinking waters of Massachusetts, and I have seen it but twice, and in different places; on one occasion, how-

ever, it was very abundant and lasted for two weeks, so that I had good opportunity to study it. It disappeared as suddenly as it came.

The odor of *Bursaria gastris* is distinctly like the odor of Irish moss, or a salt-marsh odor, such as one encounters in breezes which have passed over heaps of live seaweed. It is not disagreeable but rather fragrant, and much stronger in test tubes containing the concentrated organisms than in the original bottle from which the sample was taken. While the odor here is much stronger, the microscopical examination of the water containing the concentrated organisms reveals no *Bursaria*, for the reason that they invariably go to pieces during the process of filtering.

Cryptomonas is the cause of another well-defined and extremely characteristic odor. When concentrated these organisms give rise to an odor which, as has been said above, is strongly suggestive of candied violets. That this odor is due to the presence of oil-globules seems conclusive. The organisms are very delicate, and, like *Uroglena Americana* and *Bursaria gastris*, readily disintegrate upon the least derangement of their customary environment. I have repeatedly watched them going to pieces in my counting cell, and as one after the other breaks up, the two chromatophore plates of each organism separate, while the oil-globules enclosed by the original membrane are set free, and float about in the water. The number of oil-globules varies from one to five in each individual. *Cryptomonas* invariably disintegrates upon filtration, and in the test tubes containing the organisms of 500 cubic centimeters concentrated in 5 cubic centimeters of distilled water, the odor is always much more intense than in the large bottle from which the sample is drawn. The disintegrated forms of *Cryptomonas* are very characteristic, and I can always recognize such remains. It seems reasonable to believe provisionally that the odor of the water containing *Cryptomonas* is due to the presence of great numbers of these oil-globules, which become liberated by the diffluence of the body walls. This theory can readily explain why the odor is exaggerated in the test tubes after filtration, because in this condition not only are the organisms concentrated, but the individuals are all disintegrated, thus liberating great numbers of oil-globules. The disintegration of the cells is physical decomposition rather than chemical decomposition or decay, for it is not probable that bacterial action would always take place during the few minutes required for filtration.

The odor which has been called *aromatic* is best shown, as we have seen, when *Asterionella* or *Tabellaria* or both are present in great abundance. The filtrate of waters containing these organisms gives the odor strongly, which is driven off by heat. As with the protozoa, the cause of this odor may be explained by the presence of oil in the bodies of the organisms. It is a well-known fact that oil-particles are present in the bodies of different forms of diatoms. In *Navicula viridis* (*Navicula major*, *Pinnularia viridis*) I have counted as many as 171 oil-globules in one organism, and one of these globules measured 12 microns in diameter. In *Asterionella* and *Tabellaria* the oil-globules, although not so large nor so abundant as in the *Navicula*, are nevertheless numerous.

The odor yielded by *Asterionella* is not due to decomposition. In Waltham, in 1891, many complaints were made of the odor in the water supply. Investigation showed that the reservoir supplying the mains was crowded with *Asterionella*, and the odor was distinctly aromatic, resembling closely the odor of geranium. In certain parts of the service no odor was detected, nor was there any *Asterionella* present. Bacterial examination of the reservoir samples indicated that the odor was not due to decomposition. In one case bacterial examinations of the same water were made for several days in succession, and it was found that as the bacteria increased in number the odor decreased in intensity. The contents of the diatom body consist of a membrane, chromatophore plates, nuclei, cell sap and oil-globules, with perhaps some amylaceous products. That the odor of diatoms is an odor of growth, is shown by the bacterial examinations which were made; and the odor is not disagreeable, as it would probably be if decay were going on. The cause of the odor must then be sought for in some product of the live organism. Here, as in the case of the protozoa, we must turn to the oil-globules as most likely to cause the odor. Starch grains cannot give it, for starch has no odor; and if the odor were caused by the protoplasm or chromatin plates, we should expect to find it whenever any class of diatoms is present in abundance. By the theory of oil-globules we can account for several peculiar circumstances. For example, I have frequently observed *Asterionella* present in great abundance without detecting any odor in the infested water; whereas in other cases I have found fewer numbers, but distinct aromatic odors. Assuming that the theory of oil-globules is correct, we can explain the above peculiarity by the fact

that oil is not a continual product of the diatom frustule, nor is it always present. Oil-particles are reserve food products, and often most abundant when conjugation is about to take place. According to some diatomists, they mark the senility of the organisms.

The above organisms and their characteristic odors have been identified during the work of the Board of the last two years. Besides these, other forms have been known by other investigators to give peculiar and characteristic odors to the waters which they infest. The most noted case perhaps is the famous "cucumber odor" of the Boston water in 1878. Professor Remsen was satisfied that the odor was caused by the decomposition of a fresh-water sponge (*Spongilla fluviatilis*). F. F. Forbes, superintendent of Water Works of Brookline, Mass., has added not a little to our knowledge of odors and organisms. He has observed several cases in which the odor could be traced to a specific organism, and in many of them he is positive that the odor is formed during the life of the individuals, and not by their decomposition. Among such forms he includes *Uvella* (*Synura uvella*), *Dinobryon*, and *Asterionella*. *Volvox globator* has been reported by Mr. Rafter to cause a most disagreeable fishy taste in the water infested by these forms. He does not state whether the odor is due to the decomposition of the colonies. Mr. Rafter has also observed many other forms to which he ascribes specific odors. Among these he cites *Crenothrix*, and *Hydrodictyon*, *Cladophora*, *Nostocaceæ*, *Batrachospermum* and other algæ. Among the diatoms, besides *Asterionella* and *Tabellaria*, *Meridion circulare* has been known to produce a very distinct and characteristic odor in the water; but I have never seen reference made to any other species as a source of complaint on this account. *Synedra* has been observed in great abundance, and my experience corroborates that of Mr. Forbes, to the effect that this particular organism, in the numbers in which we usually find it in the surface waters, produces no odor.

Conclusions.

We have now arrived at certain definite theories concerning the causes of odors in drinking waters, namely, that they may be produced by the putrefactive decomposition of the body plasm through the agency of bacteria; by the excretion of certain products of growth, or by the liberation of products by the physical disintegra-

tion of the body or breaking down of the enclosing cell walls. These three causes give rise to three classes of odors, as follows: (1) odors of chemical or putrefactive decomposition, (2) odors of growth and (3) odors of physical disintegration.

In regard to the specific cause of an odor of growth or disintegration, all evidence seems to point to the importance of oil-globules, it being assumed that these are odorous, as are the odor-giving oils of some of the higher plants. In *Uroglena*, *Bursaria* and *Cryptomonas* we notice a difference in the quality of the odor, just as we do in the case of the violet, rose and heliotrope.

EXPLANATION OF PLATE.

Fig. 1. *Bursaria gastris*, showing contained food particles (*Peridinium* and *Protococcus*), oil-globules and nucleus.

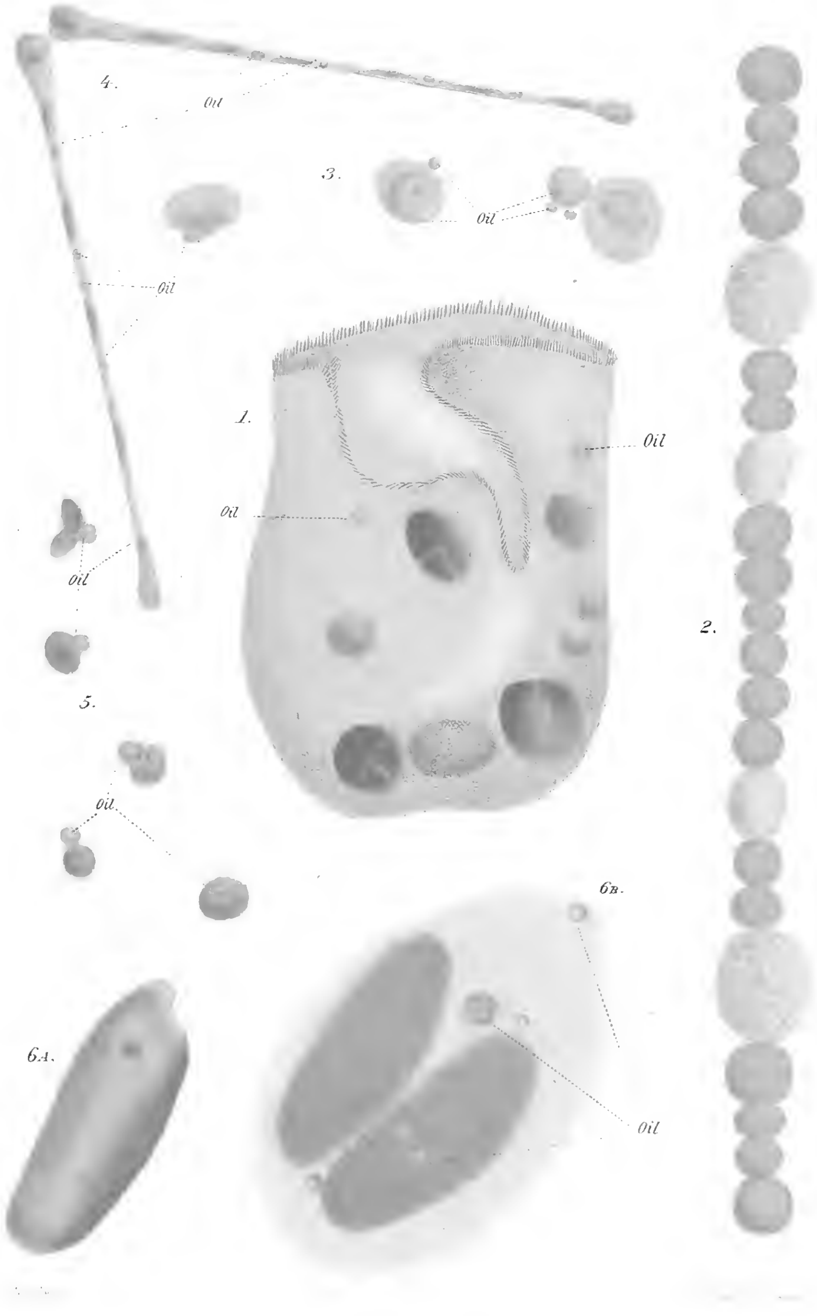
Fig. 2. A filament of *Anabæna*.

Fig. 3. Isolated monads from a colony of *Uroglena Americana*, showing position of oil-globules after exudation.

Fig. 4. *Asterionella formosa*.

Fig. 5. Isolated monads from a colony of *Volvox Globator*.

Fig. 6. A. *Cryptomonas*, normal.
B. *Cryptomonas*, disintegrated.


4.
Oil
3.
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2.
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Oil

THE SEASONAL DISTRIBUTION

OF

MICROSCOPICAL ORGANISMS

IN

SURFACE WATERS.

BY GARY N. CALKINS,

ASSISTANT BIOLOGIST OF THE BOARD.

THE SEASONAL DISTRIBUTION OF MICROSCOPICAL ORGANISMS IN SURFACE WATERS.

By Gary N. Calkins, Assistant Biologist of the Board.

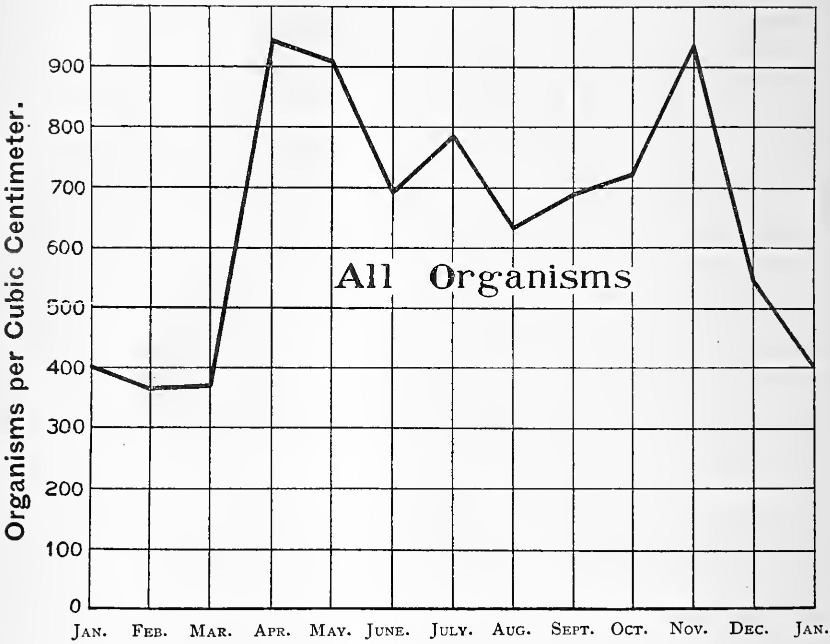
In the special report of the Board upon the Examination of Water Supplies, published in 1890 (p. 597), Mr. G. H. Parker, biologist of the Board, gave results which indicate that there is a well-marked seasonal distribution of microscopical organisms. Mr. Parker's records were based upon numbers of organisms observed during the period from July, 1887, to June, 1889. In the present paper I desire to record the results gained since that time by three years' observations with improved methods of concentration and enumeration. These results establish Mr. Parker's conclusion that the same organisms are not equally represented at different seasons.

In choosing the data for this record I have been careful to select only those waters which give comparable results. Ground waters, tap waters and waters stored in covered reservoirs have been avoided; also only those waters have been selected for which the records are complete for at least twelve consecutive months, and in most cases these records cover a period of three years. This limits the investigation to a consideration of about thirty different surface waters variously situated throughout the State.

Seasonal Distribution of All Organisms.

Under the heading "All Organisms" are included all forms which are identified and enumerated with the aid of the microscope. If enough waters are examined for a period of several years, the average number of organisms per month should indicate with considerable accuracy the seasonal distribution of the microscopical forms which infest potable surface waters. The following diagram represents such an average. It is based upon 1,082 examinations of

different surface waters, made during the three years 1890–92. In this and in all of the following diagrams the ordinates represent numbers of organisms in one cubic centimeter.



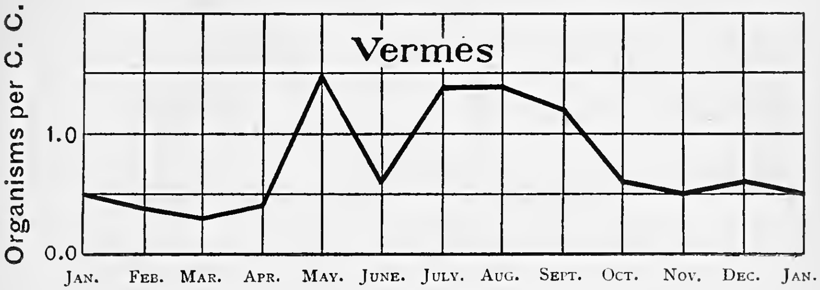
This diagram plainly shows that, in regard to numbers, microscopical organisms in drinking waters are not equally represented in the several seasons. The high numbers from March until November, and the low numbers from December until April, indicate seasonal influence.

It will be noticed that at no season of year is the average surface water free from a considerable number of organisms. The lowest number is 360 per cubic centimeter, and this includes many forms which may be found at all seasons. The diagram does not show, however, what classes of organisms are most abundant at different seasons, nor does it show what forms are present during the entire year. These must be examined separately.

A. Vermes.

Only certain species of rotifera are found in surface waters, and these but rarely. The numbers are perhaps too small to give results

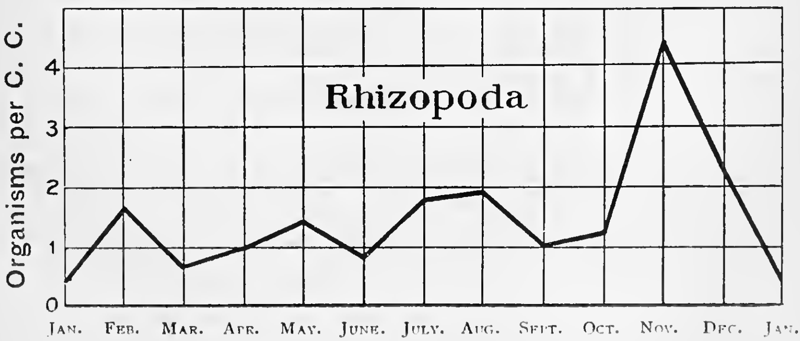
of much importance, but the following diagram represents the average monthly numbers obtained. The diagram is based upon the monthly examination of 19 waters for a period of three years.



The chief genera of rotifera included in this diagram are *Anurea*, *Polyarthra*, *Monocerca*, *Conochilus* and *Asplanchna*. The first two are relatively common, but the others are rarely observed.

B. Rhizopoda.

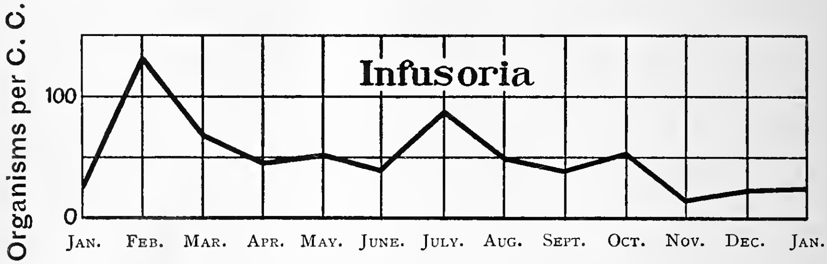
Here, as in the preceding class, the numbers are hardly large enough for safe conclusions. The following diagram, however, shows their seasonal distribution. It is based upon 720 monthly examinations of 20 waters during a period of three years.



The principal genera observed during the last three years are *Actinophrys*, *Difflugia* and *Arcella*. From the mode of life of the Rhizopoda, the comparatively large number in November, when waters in ponds and reservoirs usually turn over, is interesting and noteworthy.

C. *Infusoria.*

The infusoria are of great interest, because of their relation to odors in drinking waters. Their distribution by seasons is shown in the following diagram, which is based upon 912 monthly examinations of 26 waters during a period of three years.

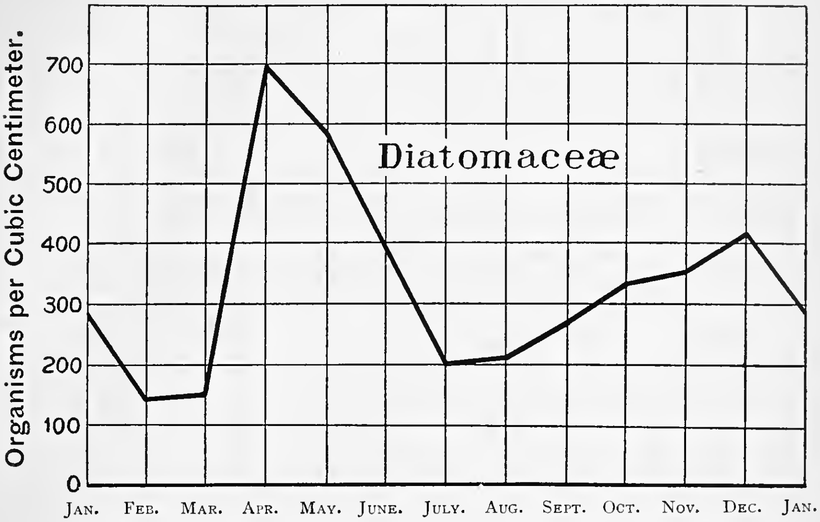


Mastigophora are by far the most common and most numerous forms of infusoria, while the ciliata are comparatively rare. Of the former the genera most frequently observed in surface waters have been *Dinobryon*, *Peridinium*, *Synura*, *Trachelomonas*, *Cryptomonas* and *Uroglena;* of the latter, *Vorticella* and *Paramœcium*. In February, and in general during the winter months, forms such as *Uroglena* and *Cryptomonas* are most likely to be found in abundance, while in summer they are rarely seen. *Dinobryon*, and *Peridinium* apparently live equally well at all seasons of the year, and *Trachelomonas* is observed in the warm months.

D. *Diatomaceæ.*

In regard to their prevalence and seasonal distribution in drinking waters, diatoms are perhaps the most interesting of microscopical organisms. Although present at all seasons of the year, they nevertheless have one particular time during which they increase

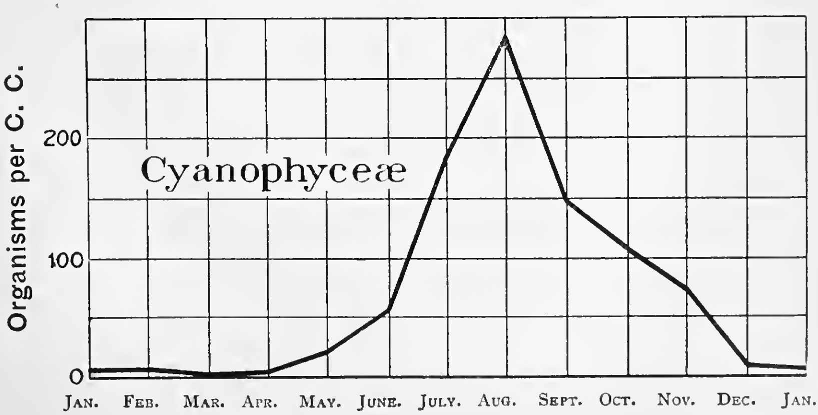
prodigiously. The following diagram is based upon 900 monthly examinations of 25 waters for a period of three years.



Some forms of diatoms exist equally well at all seasons of the year. *Synedra*, *Melosira*, *Cyclotella* and *Navicula*, for example, are found at all times. *Asterionella* and *Tabellaria* are limited rather to the spring and the fall.

E. Cyanophyceæ.

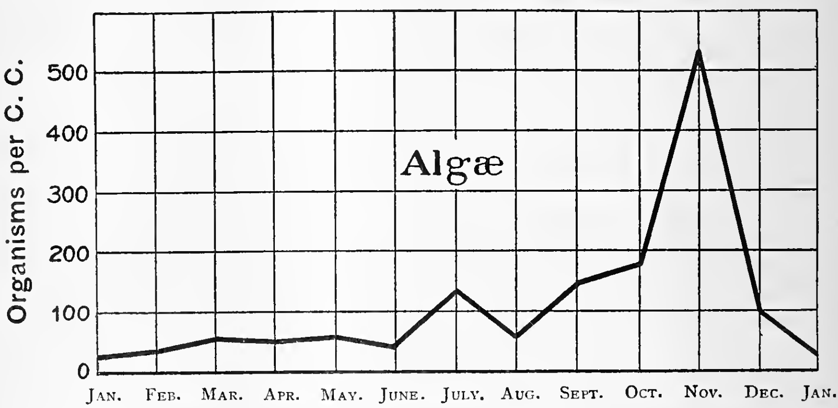
The cyanophyceæ are often the cause of disagreeable odors and appearances of water in summer. The following diagram, based upon 828 monthly examinations of 23 different waters for a period of three years, shows them to be pre-eminently a summer or hot-weather class.



Some forms of cyanophyceæ, *Clathrocystis* and *Cœlosphærium* in particular, are occasionally found during the winter months, although in very small numbers. *Anabœna* and other nostocaceæ first appear in April, and attain their greatest development in August.

F. Algœ.

Plants included under this heading comprise protococcoideæ, desmidiaceæ and the higher algæ. The latter are mostly filamentous forms growing attached to the bottoms and sides of lakes, ponds and reservoirs, and as they are rarely found suspended, they are not represented in the accompanying diagram. The desmids, like rhizopods, live on the superficial slime of ponds, or fastened to stalks and stems of water plants which are attached to the bottom. These are rarely found in suspension, unless some disturbing element distributes them throughout the water. The following diagram is based upon 912 monthly examinations of 26 different waters for a period of three years.

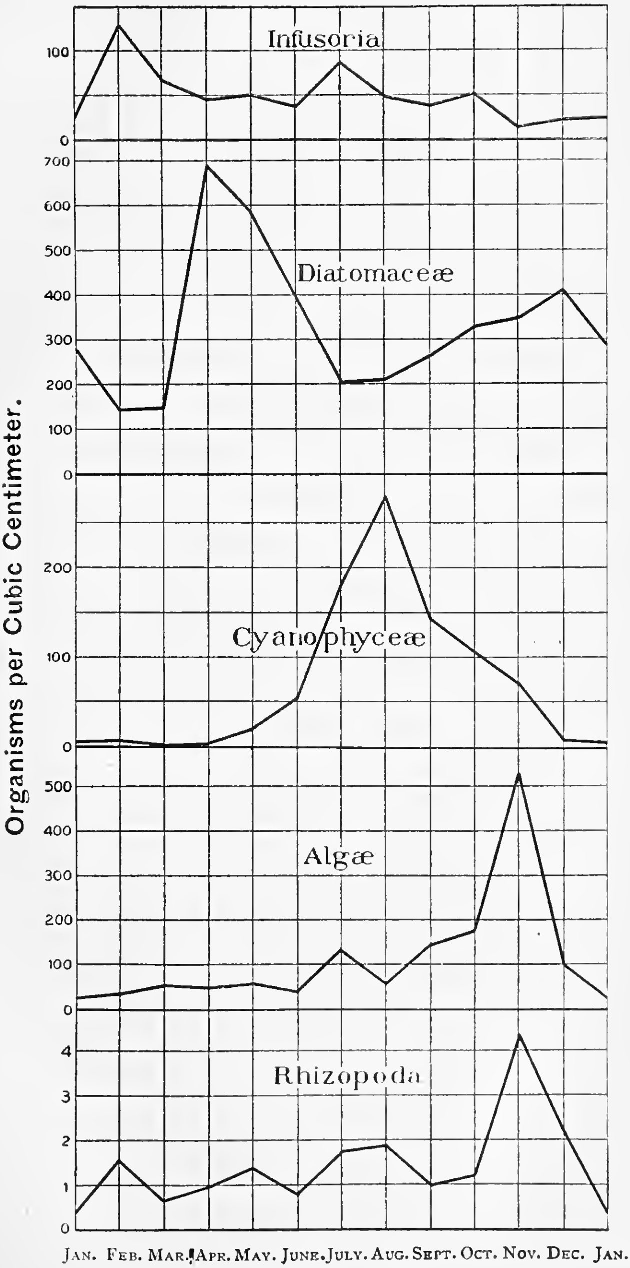


The great development in November may be partially explained by the turning over of most surface waters at that time. The most common forms which are thus seasonably distributed are *Scenedesmus*, *Protococcus*, *Staurastrum* and *Cosmarium*. All of these may be found at all seasons of the year.

Seasonal Succession of Microscopical Organisms.

From what has already been shown, it is evident that the numbers of each class of organisms culminate at a certain time, and, with the exception of the algæ and rhizopoda, no two classes culminate in the

same month. For the sake of comparison, the lines of the several classes have been arranged in one diagram.



The succession here exhibited is striking and suggestive. We probably have not yet sufficient data to account for all of the facts. It is obvious that the summer is, as might be expected, the season of the greatest development of "all organisms," while the winter is the season of relative inactivity. The enormous development of diatoms in the spring proves that these hardy plants are able to multiply during that period of lengthening days, in spite of the almost freezing temperature of the water. The relatively luxuriant development of cyanophyceæ at the end of the hot season suggests that these prefer water of high temperature. The relative excess of algæ and rhizopoda in the autumn may be due to the turning over of the ponds in which they live, a possibility which is supported by their infrequency at other seasons.

For the final explanation of these phenomena, however, further investigation is necessary.

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1892.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AT THE LAWRENCE EXPERIMENT STATION.*

By ALLEN HAZEN, Chemist in Charge.

The year 1892 is the fifth that the experimental work of the Lawrence Experiment Station has been continued. The work is carried on under the general supervision of Hiram F. Mills, C.E., a member of the State Board of Health, with the writer in direct charge. Mr. George W. Fuller is in charge of the biological department, Mr. Harry W. Clark is assistant chemist, and Mr. F. L. Fales has compiled the records and prepared the tables and diagrams showing the results of the work. Professors T. M. Drown and W. T. Sedgwick of the Massachusetts Institute of Technology are respectively consulting chemist and biologist, with a general oversight of the chemical and biological investigations.

The following subjects are treated in this paper: —

Character of the sewage.
Fats in sewage.
Fat as a clogging material.
Experiments with sand clogged by sewage.
Influence of the amount of sludge in sewage upon the rapidity of clogging.
Scraping sewage filters.
Systematic scraping.
Stratification and the effect of horizontal layers.
Filtration of sewage containing dye-stuffs.
Construction of sewage carriers.
Purification of sewage in winter.
On the area of filters to be provided.
Removal of clogged sand.
Work of filters for 1892.
Filling of experimental sewage filters.
Measurements of sewage applied to filters.
Operation of experimental sewage filters during 1892.

* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the Purification of Sewage and Water, 1890, and a similar account for the years 1890 and 1891 is contained in the Twenty-Third Annual Report of the Board for the year 1891.

Character of the Sewage.

The sewer from which the sewage for the experiment station is obtained drains the most densely populated section of the city of Lawrence, and the sewage is probably considerably more concentrated than would be the average sewage of the entire city. In addition, all of the sewage used at the station is pumped between the hours of 7 A.M. and 5 P.M., and is probably stronger than the sewage for the remaining hours of the day. On the other hand, some of the insoluble matters of the sewage are retained in the pipe leading to the experiment station, as was shown on page 456 of the Twenty-third Annual Report for the year 1891, and this to some extent balances the increased concentration, due to time and place of collection.

An experiment showing the amount of matter retained in the pipes was given in the report mentioned above (page 456). The experiment was repeated June 28, 1892, with results which differ but little from those previously given. The two experiments are as follows: —

	Total Amount Retained in Pipe. Pounds.	Calculated in Parts per 100,000 on the Sewage Conveyed since Previous Cleaning.	Average Composition of Sewage at the Outlet during this Period. Parts per 100,000.	Per Cent. of Matter Retained Calculated on the Original Composition of the Sewage.
First Experiment (Jan. 26, 1892).				
Loss on ignition,	33.40	3.7200	-	-
Fixed residue,	34.90	3.8600	-	-
Total albuminoid ammonia,	0.83	0.0900	0.7600	10.
Insoluble albuminoid ammonia,	0.83	0.0900	0.4200	17.
Oxygen consumed,	2.78	0.3100	4.5200	6.
Fats,	10.04	1.1100	*12.0000	8.
Second Experiment (June 28, 1892).				
Loss on ignition,	60.70	3.9000	-	-
Fixed residue,	101.00	6.5000	-	-
Total albuminoid ammonia,	1.50	0.9600	0.7127	12.
Insoluble albuminoid ammonia,	1.50	0.0960	0.3073	24.
Oxygen consumed,	10.50	0.6800	3.6000	16.
Fats,	21.90	1.4100	2.9000	33.

* Fifteen parts in January. Estimated 10 parts in December.

Samples of Sewage.

It has been the uniform practice from the beginning of the experiments to collect for analysis a gallon of sewage from one of the measuring basins on four or six days of the week. While the sample was intended to be as far as possible a representative one, it necessarily represented accurately only a small fraction of the total amount of sewage used; and the variations otherwise unaccounted for in the nitrogen stored in different filters, and in the chlorine of their

effluents, have at times indicated that portions of the sewage differ considerably in composition from the regular samples. The routine of the station has been conducted with such great regularity that it was by no means impossible that some filters flooded, say, uniformly in the afternoon should receive sewage of quite a different composition from those flooded in the morning. There is also considerable difficulty in mixing several hundred gallons of sewage so as to get a sample with its proper share of suspended matter.

To determine more accurately the average composition of all sewage pumped, a sample has been taken every Tuesday by collecting directly from the pump (without allowing any opportunity for sedimentation) a quantity of sewage for each lot of sewage pumped, the quantity collected being in each case proportional to the quantity pumped. Collecting the sewage directly from the pump gives of course a chance of getting a sample from a small lot of sewage of exceptional composition; but when a considerable number of such samples are mixed, error from this source is mainly eliminated, and when the analyses are averaged for a month or for a year, it should entirely disappear; and it is certainly a very great gain, to remove the possibility of sedimentation and incomplete mixing. The analyses of the sewage so collected are given as "average sewage," and should represent the average composition of all sewage applied to the filters. The results do not differ widely from those obtained from the regular sewage samples.

To determine whether the sewage applied to the different filters varied from the average, samples of the sewage applied to three of the large filters were taken during the latter part of the year. These samples were also taken from the sewage as pumped; and to avoid daily variations, which might be quite serious when only one lot of sewage was taken for the sample, a mixed sample has been prepared each week, representing each dose of sewage applied to each filter. In order to keep these sewage samples for one week without decomposition, which might seriously affect the analysis, a small amount of a mercury salt was placed in the bottle. At first mercuric chloride was used, but this of course prevented the determination of chlorine. Mercuric nitrate was excluded for a similar reason. The sulphate was tried, but owing to its slight solubility, unless special care was taken, enough would not go into solution, and the little taken up would be precipitated as sulphide, and the sewage would then putrefy badly. Later, mercuric acetate, prepared by dissolving freshly precipitated mercuric

hydrate in acetic acid, was employed with excellent results, five cubic centimeters of a solution (containing as much mercury as five cubic centimeters of saturated corrosive sublimate solution) being an ample quantity to preserve a gallon of sewage. The mercury does not affect the ammonia determination in any way. The chlorine titration in its presence is not satisfactory, and we, therefore, evaporate 50 c. c. of these samples to dryness, with a little sodium carbonate, and take up the chlorides in warm water after ignition in a radiator. The soluble and insoluble albuminoid ammonias were not determined in these samples, as early experiments indicated that some matters became insoluble in presence of the mercury. In the tables of averages the soluble albuminoid ammonia has been taken as that found in the regular samples for corresponding dates. This is an approximation to the truth, for the soluble matters are much less liable to sudden variations than are the suspended matters.

The following tables show the monthly averages of sewage samples collected in the various ways above described. The daily variations in the sewage are so thoroughly shown in the tables of analyses in the Special Report upon Purification of Sewage and Water, 1890, and in the annual report for 1891, that it is not deemed necessary to publish again the daily results in full.

Monthly Averages of Analyses of Regular Sewage Samples.

[Parts per 100,000.]

Month — 1892.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
January,	1.7676	.6835	.2724	.4111	5.66	3.52	14.3	661,000
February,	2.1719	1.0425	.3731	.6694	6.66	5.68	10.9	1,143,000
March,	2.1474	.8579	.3479	.5100	5.90	5.00	4.6	989,000
April,	2.9559	.8235	.4776	.3459	7.11	3.82	3.0	802,000
May,	2.7118	.7282	.4969	.2313	7.20	3.62	2.6	714,000
June,	2.2500	.5844	.2417	.3427	9.64	3.37	3.0	626,000
July,	2.4176	.6282	.2759	.3523	12.18	3.21	4.0	504,000
August,	2.4333	.7939	.2755	.5184	11.85	4.63	4.5	829,000
September,	2.5612	.7817	.3294	.4523	9.31	4.24	3.9	800,000
October,	2.8562	.6819	.3056	.3763	8.70	4.22	3.3	927,000
November,	2.4444	.6428	.3222	.3206	8.35	4.50	3.8	854,000
December,	2.7028	.7450	.4017	.3433	7.34	4.80	9.9	863,000
Average,	2.4517	.7495	3433	.4062	8.33	4.22	5.6	809,000

The above analyses represent four samples each week taken from one of the sewage tanks, usually in the morning, and the results are directly comparable with the analyses published for previous years.

Monthly Averages of Analyses of Average Sewage Samples.

[Parts per 100,000.]

Month — 1892.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.	Fats.
January,	1.9375	.6925	.3075	.3850	5.15	3.90	-
February,	2.4125	.7325	.3800	.3525	7.02	4.30	3.5
March,	2.5000	.6760	.3700	.3060	5.83	4.06	3.5
April,	2.7000	.7100	.3675	.3425	6.06	3.40	3.0
May,	2.7000	.6940	.3540	.3400	7.75	3.60	1.4
June,	2.3375	.5400	.2400	.3000	9.29	3.50	1.7
July,	2.7000	.6225	.3200	.3025	9.42	3.12	-
August,	2.5800	.6940	.2900	.4040	9.93	4.08	2.3
September,	3.1000	.7175	.3100	.4075	8.99	4.27	4.5
October,	3.5125	.8225	.3750	.4475	9.87	4.27	3.7
November,	2.7100	.7660	.3560	.4100	8.13	4.50	5.8
December,	2.9750	.9275	.4225	.5050	12.09	5.10	7.6
Average,	2.6804	.7162	.3410	.3752	8.29	4.01	3.7

These analyses represent average samples of all the sewage pumped for each Tuesday in the year.

Monthly Averages of Mixed Samples Representing all the Sewage Applied to Three Filters.

[Parts per 100,000.]

Month — 1892.	Free Ammonia.			Albuminoid Ammonia.			Oxygen Consumed.			Chlorine.		
	Filter No. 1.	Filter No. 6.	Filter No. 9.	Filter No. 1.	Filter No. 6.	Filter No. 9.	Filter No. 1.	Filter No. 6.	Filter No. 9.	Filter No. 1.	Filter No. 6.	Filter No. 9.
July,	2.5750	2.8000	-	.8950	1.0450	-	3.70	5.00	-	-	-	-
August,	2.4500	2.7500	2.6750	.8350	1.0075	.7925	3.47	4.63	3.63	-	-	-
September,	2.8125	3.2750	3.0250	.6325	.8550	.8425	3.77	4.50	4.15	8.64	8.07	8.73
October,	3.2800	4.0250	3.2125	.8760	1.1025	.7925	4.72	6.47	4.67	11.68	12.11	8.39
November,	2.6000	2.6250	2.5625	.8375	.8775	.8150	5.92	6.12	5.15	10.64	7.20	6.62
December,	2.6700	2.7800	2.4800	.9540	1.0320	.7580	6.18	6.34	4.98	7.33	10.23	9.94

Monthly Averages of Supernatant Liquid from Settled Sewage for Filter No. 32.

[Parts per 100,000.]

Month—1892.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
January,	1.6625	.4250	.2475	.1775	4.82	2.67	1.0	1,059,000
February,	2.0875	.5450	.3275	.2175	7.50	3.32	3.8	668,000
March,	2.2300	.5200	.2960	.2240	5.83	3.22	2.4	685,000
April,	2.8500	.6550	.3775	.2775	6.70	3.05	2.3	627,000
May,	2.7500	.5875	.3975	.1900	6.65	2.85	1.0	380,000
June,	2.0500	.3860	.2180	.1680	9.90	2.52	1.7	390,000
July,	2.2000	.4450	.2750	.1700	16.58	2.27	-	260,000
August,	2.2500	.4480	.2820	.1660	8.54	2.68	1.9	896,000
September,	2.5200	.4325	.2650	.1675	9.02	3.02	2.5	740,000
October,	2.8875	.4325	.3400	.0925	8.65	3.05	1.7	787,000
November,	2.3500	.4880	.2980	.1900	6.97	3.66	2.6	439,000
December,	2.7125	.6050	.4175	.1875	6.80	4.57	6.0	967,000
Average,	2.3796	.4975	.3118	.1857	8.16	3.07	2.4	658,000

These analyses represent the supernatant liquid after the sewage represented by the regular sample had been allowed to settle for four hours.

Monthly Averages of Sludge Applied to Filters Nos. 26, 27 and 28.

[Parts per 100,000.]

Month—1892.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
January,	1.6750	2.3400	.3075	2.0325	5.02	10.55	40.0	1,899,000
February,	2.1375	2.4050	.3700	2.0350	7.50	13.15	54.2	2,224,000
March,	2.1600	2.9460	.4520	2.4940	6.03	13.88	-	2,098,000
April,	3.2250	2.4400	.4875	1.9525	7.01	9.30	-	1,299,000
May,	3.0250	2.5525	.4775	2.0750	6.77	9.32	-	1,766,000
June,	2.1000	2.0800	.2400	1.8400	9.97	9.22	-	1,029,000
July,	2.4625	2.3025	.3325	1.9700	16.72	9.92	-	1,376,000
August,	2.5200	2.4880	.3540	2.1340	8.69	11.96	-	1,363,000
September,	2.7250	2.2250	.3425	1.8825	9.19	9.45	-	1,912,000
October,	3.0000	2.3375	.3375	2.0000	8.75	10.17	-	1,375,000
November,	2.3200	1.6060	.3340	1.3720	7.10	7.52	-	1,458,000
December,	2.7625	2.2675	.4700	1.7975	6.89	11.22	-	2,700,000
Average,	2.5094	2.4158	.3754	2.0404	8.30	10.47	-	1,708,000

These analyses represent the sludge which settled from the sewage used for Filter No. 32, mixed with so much of the supernatant liquid that its volume was one-sixth of that of the original sewage.

Comparing the average results of analyses of sewage from the different sources, we have for the *regular* and the *average* samples during the year 1892 the composition given below.

Analyses of Regular and Average Sewage.

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.
		Total.	Soluble.	Insoluble.			
Regular, ...	2.4517	.7495	.3433	.4062	8.33	4.22	5.6
Average, ...	2.6804	.7162	.3410	.3752	8.29	4.01	3.7

The differences between the two are very slight; the average has more free ammonia but less insoluble albuminoid ammonia. The soluble albuminoid ammonia, chlorine and oxygen consumed are substantially the same. The regular sewage contains more fat.

The analyses of the sewage applied to different filters are complete for the last four months of the year only. Comparing this sewage with the *regular* and *average* sewage for the same period, we have: —

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Con-sumed.
		Total.	Soluble.	Insoluble.		
Regular, ...	2.6411	.7128	.3397	.3731	8.42	4.44
Average, ...	3.0744	.8084	.3659	.4425	9.77	4.53
For Filter No. 1, ...	2.8406	.8250	.3400*	.4850	9.57	5.15
For Filter No. 6, ...	3.1762	.9667	.3400*	.6267	9.40	5.86
For Filter No. 9, ...	2.8200	.8020	.3400*	.4820	8.42	4.74

* Estimated as equal to that in the regular sample.

Here we find that the regular sewage is in every way the most dilute of any sewage. The average sewage differs but little from that applied to filters No. 1 and No. 9, but the sewage applied to No. 6 is considerably more concentrated. It is evident that the regular sewage does not represent accurately the quality of sewage

applied to the filters, and that for precise calculations analyses of the sewage actually applied to any particular filter are necessary. At the same time the variations are not great enough to vitiate earlier conclusions drawn from a wide range of fairly concordant results.

The effect of settling sewage without the addition of chemicals is well shown by the analyses of regular sewage and the sewages applied to filters No. 32 and Nos. 26, 27 and 28.

Effect of Allowing Sewage to Settle.

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
Regular,	2.4517	.7495	.3433	.4062	8.33	4.22	5.6	809,000
Supernatant,	2.3796	.4975	.3118	.1857	8.16	3.07	2.4	658,000
Sludge,	2.5094	2.4158	.3754	2.0404	8.30	10.47	-	1,708,000

Of the sewage as drawn, 34 per cent. of the total and 55 per cent. of the insoluble albuminoid ammonia were removed by sedimentation; and also 27 per cent. of the oxygen consumed, 57 per cent. of the fat and 19 per cent. of the bacteria.

Fats in Sewage.

Commencing January, 1892, the quantities of fats and fatty acids in the various sewage samples were determined. In the earlier months 100 cubic centimeters of the sewage under examination were evaporated to dryness with 1 cubic centimeter of normal sulphuric acid, and the residue extracted with ether. The acid is used to decompose soaps, and it is entirely insoluble in ether. Later it was found to be more convenient and accurate to evaporate successive samples from the same source in the same dish, protected from dust, and at the end of the month extract and reckon the fats obtained on all the sewage evaporated in that dish during the month. In the following table are shown the fats in the sewages from the different sets of samples examined, the figures given being the average of weekly determinations for the first half of the year, and average results as described above for the remaining months: —

Fats in Sewage.

[Parts per 100,000.]

Month — 1892.	Regular Samples.	Average Samples.	Supernatant liquid from Settled Sewage. Filter No. 32.	Sludge from Settled Sewage. Filters 26, 27 and 28.
January,	14.3	-	1.0	40.0
February,	10.9	3.5	3.8	54.2
March,	4.6	3.5	2.4	-
April,	3.0	3.0	2.3	-
May,	2.6	1.4	1.0	-
June,	3.0	1.7	1.7	-
July,	*4.0	-	-	-
August,	4.5	2 3	1.9	-
September,	3.9	4.5	2.5	-
October,	3.3	3.7	1.7	-
November,	2.8	5.8	2.6	-
December,	9.9	7.6	6.0	-
Average,	5.6	3.7	2.4	-

* Estimated.

The average samples of sewage contain somewhat less fat than the regular samples, the latter, in general, representing the early morning sewage, while the former of course represent the entire day. The winter sewage contains much more fat than the summer sewage; but this may be in part due to the greater quantity retained in the sewer pipes in warm weather. The only two experiments upon this point show 8 per cent. retained in December and January, while 33 per cent. was retained in April, May and June.

In the settled sewage the bulk of the fat is found in the sludge. The fat which settles may be in the form of a heavy insoluble soap, or it may be attached to particles of sand. Of course fat by itself would float. At least a part of the fat remaining in the upper portion of the sewage is in solution as soap.

Fat as a Clogging Material.

It has seemed not unreasonable to suppose that the small quantity of fat carried by the sewage played an important part in the clogging of the surface sand of filters long in use. This was discussed in the Twenty-third Annual Report for the year 1891. Unfortunately, we have no records of the quantities of fats in the sewage

and in the sands of the filters prior to 1892, but during the past year some new facts have been obtained.

In March, 1892, the quantity of fat in the sand of Filter No. 6 was carefully determined and found to be 14 pounds, of which practically all was within two or three inches of the surface. The quantities in Filters Nos. 1 and 2 could not be so accurately determined, on account of the ridges and trenches, which make the calculation very complicated. The results obtained, however, indicated that the quantity of fat was approximately equal to the quantity of organic nitrogen stored, or 16 pounds in No. 1 and 10 pounds in No. 2, at the end of 1892. If we assume that all the sewage which was applied to those filters from the beginning, January, 1888, contained as much fat as the regular samples during 1892, namely, 5.6 parts in 100,000, we have the following figures: —

	Filter No. 1. Pounds.	Filter No. 2. Pounds.	Filter No. 6. Pounds.
Fats applied in sewage,	234	129	136
Fats stored in sand,	16	10	14

Even if we allow a very large margin for possible errors, it is still apparent that only a small fraction of the fats of the sewage were retained in the sand.

We have another experiment upon the same point, in which the analytical results are more complete than in these calculations. A solution of soap was applied to Filter No. 12 (Twenty-third Annual Report for 1891, page 535). The actual amount of soap applied was 1,383 grams, containing 968 grams of fatty acid. None of these fatty acids passed into the effluent, but at the end of the experiment the sand contained only 384 grams, and two months later a single sample showed that nearly half the fat near the surface had been removed.

It is clear that fat does not accumulate in sand in such a way as to choke a filter. It is, however, possible that, instead of being completely oxidized and destroyed, it is oxidized to some stable compound, insoluble in ether, which clogs the sand. The experiment with soap mentioned above, indicated something of the sort, for after applying the soap the sand was badly clogged, and its condition did not materially improve as the fat disappeared from the sand. The

fats are not present as insoluble soaps, for samples have repeatedly been extracted with ether after heating with hydrochloric acid without yielding additional quantities of fat.

Experiments with Sands Clogged by Sewage.

In the spring of 1892 the surface sands were removed from Filters Nos. 1, 5 and 6; in the cases of No. 1 and No. 6 because they were clogged, in No. 5 for a change in the experiment. The removed sands were piled up, and in October determinations of albuminoid ammonia were made as follows: —

	Filter No. 1.	Filter No. 5.	Filter No. 6.
Date of removal,	June 2.	April 1.	March 29.
Original albuminoid ammonia, parts per 100,000,	56	23	70
Albuminoid ammonia, October 18, parts per 100,000,	44	15	53
Per cent. remaining in sand,	78	65	76

In each case there was a considerable reduction in albuminoid ammonia during the summer.

A portion of the sand removed from Filter No. 6 because it was clogged was placed in a twenty-inch filter, and water applied at the rate of 51,400 gallons per acre daily; later sewage was applied. At first a very poor effluent was obtained, but the results improved, and after five months the filter commenced to do fair work. It has improved steadily in its action until it now compares favorably in its work with some other filters composed mainly of clean sand. Further information with regard to this experiment may be found on a subsequent page under the heading Filter Tank No. 11A.

This is a very interesting and important phenomenon, and requires thorough investigation. A sand which had become so clogged that in a thin layer it prevented the satisfactory operation of a filter, upon being removed and placed by itself in a filter five feet deep, acquired after a time the power of purifying sewage as it would not do when supported by clean sand.

I am inclined to think that the case is parallel to the experiments made with Filters Nos. 5A and 9A, described under the heading "Stratification" (page 409). The effect of the continued use of sand and the storage of organic matters is equivalent to the addition of much finer material to the sand. Clogged sand acts like fine sand.

When it is supported by the same kind of sand all goes well; but when it is supported by clean sand (that is, coarser sand) the clean sand cannot draw the water out of the dirty sand, a saturated layer results, and bad work follows.*

When sewage is first applied to a clean filter, the bulk of the sludge is retained on the surface, forming a scum. As long as the scum does not become too thick to dry and roll up between doses, all goes well. If the scum becomes too thick to roll up, it forms a continuous cover over the surface, and excludes air. When this scum is raked its continuity is broken, ventilation is obtained, and all goes well again; but when the entire body of sand to the depth disturbed by the rake becomes filled with sludge, so that the sand below is no longer able to draw the water out of it, the filter is clogged. After Filter No. 6 reached this condition, it was still continued in use for a time with all the sewage which could be made to pass, with the probable result that the sand became charged, in addition to the difficultly decomposable matter, with a large quantity of oxidizable matter which would ordinarily have been destroyed. When Filter No. 11 was filled with this material from No. 6, it is my idea that this oxidizable matter claimed all the oxygen which could be got into the sand, even with the aid of the aspirator which was used for a time, and that there was no excess of air to allow complete purification or nitrification until, after some five months, the readily decomposable matter had been so far removed that air enough for the remainder and also for the applied sewage began to be present in the pores of the sand.

In the cases where the upper foot of sand in some of the small filters has been inverted, the conditions are not quite comparable to the deep ploughing of a field. In the filters the sand is carefully turned and left in definite layers, while in a ploughed field the clogged sand would be irregularly distributed with channels perhaps of comparatively clean sand between, and there would be no regular horizontal line of separation between the clogged and clean sand capable of forming a water seal.

Influence of the Amount of Sludge in Sewage.

It was shown in the Twenty-third Annual Report for 1891 that the amount of clogging material stored was directly proportional to the sludge in the applied sewage, and that a concentrated sewage

* Compare Twenty-third Annual Report for 1891, page 438.

would choke a filter faster than a more dilute one. During the past year an experiment has been made with sewage from which a portion of the sludge was removed by settling. Filter No. 32 received such sewage from Dec. 5, 1891, to August, 1892, at the rate of 191,300 gallons per acre daily, and at the end of that time the surface was clogged so that sewage could not be applied at that rate with good results. Five inches of sand were then removed and examined. The results are as follows: —

Sand Samples.

[Parts per 100,000.]

Number.	Depth. — Inches.	Albuminoid Ammonia.	Nitrogen.	Nitrogen. — Pounds.
677,	0-5	46.6	76.	.0456
678,	5-12	8.3	13.	.0109
679,	12-24	2.2	3.	.0043
Total,	-	-	-	.0608

Average analysis of 1,536 gallons of sewage applied: free ammonia, 2.3000; albuminoid ammonia, .5250; insoluble albuminoid ammonia, .2343.

	Pounds.	Per Cent.
Total nitrogen applied,	.350	100
Total nitrogen in effluent,	.251	72
Total nitrogen in sand,	.061	17
Total nitrogen lost,	.038	11

	Pounds.	Per Cent. Stored.
Total nitrogen applied,	.350	17
Total organic nitrogen applied,	.106	57
Insoluble organic nitrogen applied,	.038	(159)

Sand removed at the rate of 15.7 yards per million gallons sewage.

The storage of organic matter was greater and the filter became seriously clogged with less storage than with filters operating at lower rates. The amount of sand removed was also greater, but it is not believed that this was so much due to the quality of sewage as to the rate.

Of the large filters, No. 2 was badly clogged in the spring of 1892, although it is not entirely clear whether it was surface clogging or the clogging of stratified layers, as in Nos. 6 and 9, which was causing the trouble. Grass was sown upon the sand, and the

dose of sewage reduced to 13,000 gallons per acre daily from March to May, and then increased to 20,000 gallons June 1, and still further increased in September. With the reduced dose the effluent improved, and by September very complete purification was obtained. Many results obtained in the earlier years confirm the general proposition that an amount of clogging which prevents good work at a certain rate will still allow purification at a lower rate.

Our present knowledge in regard to the conditions of clogging may be summarized as follows: —

1. Other conditions being the same, the clogging of a filter is proportional to the amount of sludge carried by the applied sewage. The sewage used at the experiment station is day sewage, and probably stronger than average twenty-four-hour sewage; but, on the other hand, it deposits some of its sludge in the sewer, and is to that extent less concentrated than average sewer sewage.

2. Other conditions being the same, a larger proportion of the sludge of the applied sewage is stored at a high rate of filtration than at a lower rate.

3. The same quantity of matter stored causes more trouble at high rates than at lower rates.

4. The condition in which the clogged sand exists on the filter has an important influence upon the results obtained, and it is not clear that the most favorable conditions have as yet been secured.

5. The clogged sand by itself becomes slowly oxidized, but to what extent is as yet uncertain.

6. The clogged sand under some conditions may serve as a filtering material with good results.

Scraping Sewage Filters.

Three of the large filters have been scraped during 1892, to remove clogged material.

Filter No. 1 was scraped June 2, after being in use four years and five months, and filtering 583,000 gallons. It was filtering at that time 108,000 gallons per acre daily, with incomplete nitrification. After scraping, nitrification at once greatly increased, showing that the clogging was in the upper sand, which was removed. The sand removed averaged five inches in thickness, equal to 3.36 cubic yards, or 5.8 yards per million gallons of sewage filtered.

Sand Analyses. Filter No. 1.

Depth below Original Surface.	Per Cent. of Water.		Parts per 100,000.		Pounds of	
	Weight.	Volume.	Albuminoid Ammonia.	Nitrogen.	Sand.	Nitrogen.
0-5	-	-	56.0	91.2	9,580	8.73
5-8	5.3	9.0	20.5	32.8	5,750	1.89
8-12	7.0	12.0	14.	22.1	7,670	1.69
12-24	-	-	7.5	11.4	23,000	2.62
24-36	6.5	11.0	4.9	7.1	23,000	1.63
36	-	-	4.9	7.1	23,000	1.26
48	-	-	3.0	3.9		
60	-	-	2.8	3.6	23,000	.86

	Pounds.
Total nitrogen in sand of the filter, ...	18.68
Removed by scraping, ...	8.73
Remaining after scraping, ...	9.95

In making the above calculation, the one part in 100,000 nitrogen in the original sand was deducted from the results.

Filter No. 6 was scraped March 29, 1892, two inches deep. The material removed contained 70 parts in 100,000 albuminoid ammonia, and 90 parts of fatty acids. The tank had filtered 317,000 gallons of sewage, and the sand removed was 1.344 yards, or at the rate of 4.2 yards per million gallons treated. The scraping did not materially improve the condition of the filter, for reasons given under "Stratification" (page 409).

Filter No. 9 also was scraped, May 20; but investigation showed that the peculiar action of the filter before scraping was not due to the clogging of the surface, but to stratification. The results have no interest in this connection.

Systematic Scraping.

The scrapings just referred to were the removal of matters accumulated in several inches of sand for over four years. An experiment has been made upon Filter No. 9 to learn the effect of repeated scraping, instead of the weekly raking given the other filters. At the commencement of the experiment, July 20, the surface had already been raked for two months to a depth of about one inch each week. On September 9 the scum on the surface had curled up, and

the thickest of it was removed. September 19 the surface was becoming clogged, and no sewage was applied, and on September 20 the surface was scraped; and it was also necessary to scrape again October 7 and November 9, in order that the full volume of sewage might pass, — 100,000 gallons per acre daily.

The facts in regard to the scrapings are given in the following table: —

Date — 1892.	Weight of Material Removed in Pounds.			Dry Material. Parts per 100,000.		Nitrogen Removed.	Calculated Depth of Sand Removed.	Volume of Sand Removed.
	Wet.	Dry.	Per Cent. of Water.	Albuminoid Ammonia.	Organic Nitrogen.	Pounds.	Inches.	Cubic Yards.
Sept. 9,	45.7	43.14	5.6	360.	590.	.254	-	-
Sept. 20,	656.	633.	3.5	115.	190.	1.203	0.40	0.27
Oct. 7,	965.	886.	8.0	58.	96.	.850	0.53	0.34
Nov. 9,	990.	896.	9.5	60.	99.	.887	0.53	0.34
Total,	-	2458.	-	-	-	3.194	1.46	0.95

The filter has been in operation with its full dose of sewage up to Feb. 1, 1893, without further scraping. It has received in all, since the sand was clean, from May 20, 1892, to Feb. 1, 1893, about 113,000 gallons of sewage, and the scraping reckoned on that quantity is 8½ cubic yards of sand per million gallons.

The quantities of total nitrogen, organic nitrogen (calculated as twice the nitrogen of the albuminoid ammonia) and insoluble organic nitrogen applied in the sewage and removed by scraping at the different dates are as follows: —

Filter No. 9.

Date — 1892.	Quantities in Pounds.				Per Cent. of Insoluble Organic Nitrogen in Sand Removed.
	Total Nitrogen Applied.	Total Organic Nitrogen Applied.	Total Insoluble Organic Nitrogen Applied.	Organic Nitrogen in Sand Removed.	
Sept. 9,	13.	4.8	2.78	.25	9.
Sept. 20,	15.	5.4	3.13	1.46	47.
Oct. 7,	17.	6.1	3.56	2.31	65.
Nov. 9,	20.	7.1	4.19	3.19	76.
Dec. 31,	27.	9.5	5.43	-	-

The quantity of nitrogen removed up to the date of the last scraping was 76 per cent. of the insoluble organic nitrogen applied, which agrees well with the average result, 74 per cent. for all filters, given in the Twenty-third Annual Report for 1891, p. 452.

The filters used for the disposal of sewage at Gardner, Mass., are systematically scraped, with a two-day interval of applying sewage, and apparently with excellent results.

Stratification and the Effect of Horizontal Layers.

In all the filters filled during the earlier years of the Experiment Station, the filtering material was put in position by throwing it into water. This method always results in some stratification, the larger particles settling at once to the bottom, while the finer grains remain longer in suspension; and in case the process of filling is interrupted, even for a few minutes, the finer particles settling out form a continuous layer of much finer sand.

The amount of stratification in the different filters and its influence have probably varied widely. Some filters have been entirely ruined by it, while, so far as known, no unfavorable effect has been produced in other cases. While it can hardly be doubted that a marked stratification has some effect upon the operation of a filter from the first, the full effect is only obtained after a longer or shorter period of actual use. The layer of fine sand retains minute particles either of mineral or of organic matters, which are able to pass the ordinary sand, and continues to accumulate such matters until it becomes clogged, preventing the passage of air and water, and stopping the action of the filter.

One of the first cases of this kind was Filter No. 3A, described on page 493 of the Twenty-third Annual Report for 1891. There the clogging was in a stratified layer of fine sand a short distance below coarse sand. The next cases investigated were two water filters, Nos. 35 and 36, filled with a somewhat mixed sand (10 per cent. finer than .26 millimeter; uniformity co-efficient, 6.0) with a layer of loam; all thrown into water. The quantity of water which could be made to pass these filters was much smaller than had been expected from the material, and it was supposed that the loam layers limited the flow. It was found, however, upon removing the loam, that the quantities of water passing did not increase, and that the filters had been limited in their action by stratified layers in the

body of the sand. These filters had been in operation only three months at the time when they became practically impervious.

Filter No. 9A had been in operation a little over a year, filtering sewage at the rate of 103,000 gallons per acre daily, with very complete purification, when poor results began to be obtained. It was at first supposed that the difficulty was surface clogging; but repeatedly disturbing and scraping the surface did not improve matters, and after some months of poor work a thorough investigation, in May, 1892, showed the presence of numerous fine stratified layers from top to bottom of the filter, and it was these layers which limited the capacity of the filter. They were not horizontal, nor did any one layer cover the entire area of the filter.

On several of the layers water was standing, while others still allowed the passage of water, but remained saturated, preventing the passage of air. These layers, which of course existed during the excellent work of the first year, were unable in themselves to prevent the satisfactory operation of the filter; but when they became clogged by matters retained from the passing sewage, they became impervious, and choked the filter. A mechanical analysis of one of these layers showed that while 10 per cent. of the whole body of the sand was finer than .17 millimeter, 10 per cent. of this layer was finer than .05 millimeter.

The stratification in Filter No. 6 was less marked than in No. 9, and the filter operated with no apparent bad results from it for over four years. In the spring of 1892, however, the filter was doing poor work, and the removal of the dirty surface sand did not materially improve its condition; afterward the sand was spaded up six inches deep without effect. A careful examination showed stratification 8 to 10 inches below the surface, and when this was broken by digging up the sand 18 inches deep, the filter began to do good work again.

A similar condition was obtained with Filter No. 4, but in this case the clogging was at the junction of coarse and fine sand, and not in a layer stratified when the filter was constructed by throwing the material into water, although such layers are known to be present in the filter. In this case sewage was applied to a trench filled with coarse sand dug in the extremely fine sand of the filter. This arrangement worked satisfactorily for some three years, at the end of which

time the filter became clogged on the top of the fine sand where it joined the coarse sand.

In all the above cases the direct cause of trouble was a coarser above a finer sand. It is not probable that coarser sand above finer sand will invariably be followed by bad results, and it seems almost impossible to formulate any general rules in regard to the matter. It can be said, however, that in general such a condition is more or less dangerous, and that the danger increases with the coarseness of the upper and with the fineness of the lower sand, and that, probably, clogging would be much more rapid near the surface than below a considerable depth of sand, which would serve to filter the sewage before reaching the junction.

Another and entirely different effect of the combination of different sands is obtained when a fine sand is placed above a coarser one. The best example of this condition is furnished by Filter No. 5A. This filter at first contained a fine screened gravel (effective size * 1.40 millimeters), which was too coarse to give the best purification of sewage, but still allowed fair chemical purification with single doses of $1\frac{1}{2}$ per cent. of the volume of the filter. One of the greatest practical difficulties in the operation of a filter of such coarse material is to secure an even distribution of the sewage. The tendency is for the sewage to run down in limited areas near the point of application, while the rest of the filter is practically unused. It was thought that a layer of medium fine sand at or near the surface would tend to correct this tendency and improve the distribution. Accordingly, March 29, 1892, the upper three inches of gravel were removed and replaced by one inch of coarse sand, effective size .32 millimeter, one inch medium sand, effective size .19 millimeter, and one inch coarse sand, same as above. The distribution was improved, but there was a choking on the surface of the second inch of fine sand. At the time the change was made the temperature was just commencing to rise rapidly in the spring, and the filter was improving and would undoubtedly have continued to improve in its action had no change been made. For this reason it is not certain that the largely increased quantity of nitrates during April was due to the cover of fine sand. The organic matters in the effluent were increased rather than diminished by the change.

* The term "effective size" is used as equivalent to the coarsest particles of the finest ten per cent. of the sand.

It was shown in the Twenty-third Annual Report for 1891, p. 432, that fine sands will hold their pores full of water by capillarity for certain definite distances above their drainage levels, the distances depending upon the fineness of the sand. If we have a considerable layer of fine sand underdrained, upon the top of which sewage is put, the weight of the column of water in the pores of the sand and the cohesion of the water will draw the sewage down into the sand until a point is reached where the capillary attraction is able to hold the weight of the water in the remaining saturated layer. The upper part of the sand is thus comparatively dry, leaving only the bottom of the sand extremely wet. If, however, the fine sand is supported by a coarser sand, the downward attraction is not so strong, owing to less cohesion of the water in the larger partially filled pores, and if there is much difference in the sizes of the pores of the two sands, the coarse sand will not draw the water out of the fine sand, but the bottom of the latter will remain saturated with water, although thoroughly underdrained by the coarse sand.

In Filter No. 5A, with the above-mentioned covering of fine sand, the inch layer of .19 millimeter sand always remained saturated with water. On applying sewage it passed freely, but the saturated layer acted as a water seal, and prevented the passage of air. If the exclusion of air had been complete, the high nitrification and fair purification which were actually obtained during April would have been impossible; but changes in temperature and barometer, and variations in the quantity of water in the filter at different hours of the day, caused a considerable change of air through the underdrains, which were open to the air below; and, in addition, the sewage, running rapidly upon the surface, sometimes cut holes through the single inch in depth of fine sand, and allowed a free vent for the exchange of air until the break was repaired. The high free ammonia and organic matter always present in the effluent showed, however, that the ventilation so secured was inadequate for complete purification. The fine sand retained many of the solid impurities of the sewage, and, since it was always saturated with water, there was no opportunity for aeration and oxidation, so that it very rapidly became clogged, and after only six weeks the full quantity of sewage could not be filtered. As the clogging was in the fine sand beneath the surface of the filter, raking was without effect, and the effluent rapidly deteriorated in quality, until nitrification

had entirely ceased. At the same time the quantity which could be passed was very unsatisfactory in amount.

There was reason to believe, however, that the direct cause of failure might be at the junction of the coarse sand above the fine sand, and not at the lower junction of fine sand over coarse sand; and it was determined to repeat the experiment in such a way as to eliminate this uncertainty. On June 2 the upper two inches of sand were removed and replaced with clean .19 millimeter sand, so that there was nowhere in the filter a coarser over a finer sand, but always a finer over a coarser. The layer of .19 millimeter sand being two inches thick, and its saturated layer only one inch thick, the upper inch of surface sand had an opportunity to become to some extent dry, and was therefore less likely to clog than with the earlier arrangement. The results during the following month were the best which had ever been obtained from that filter with a corresponding dose of sewage, although even then not equalling those obtained from filter No. 9A, which was filled with 5 feet of sand of the same size as the surface sand of No. 5A, and received sewage at a slightly greater average rate. The fine sand above the coarse in No. 5A acted as before as a water seal, and ventilation must have taken place almost entirely from the underdrains; for on July 15 the outlet of the underdrain was trapped so as to allow the free passage of the effluent but to exclude air, and following this change nitrification stopped and the organic matters largely increased in the effluent. There was, however, some ventilation even with this arrangement. The water seal above, with the size of sand used, could only resist a pressure of one inch of water, and with changes of temperature or barometer some air must have been forced through. Also the sand occasionally became perforated by the sewage, and allowed for a short time a free passage of air. It was probably owing to these causes that nitrates were occasionally observed in samples of the effluent between other samples in which there was little or no evidence of nitrification. The full quantity of sewage was regularly passed and delivered in a well-strained and partially purified condition, but owing to the absence of oxygen in the filter iron oxide was reduced by the organic matter and iron passed into solution as protoxide. This iron coming in contact with air caused the effluent to turn red by precipitating iron oxide. On October 8 the trap on the outlet was removed, but there was not sufficient exchange

of air to materially improve the condition of the filter; and on October 31, no improvement having been noticed, the fine sand was removed entirely, to again test the purifying power of the gravel by itself. The nitrates in the effluent, which had for a month been entirely absent, at once rose to 1.20 parts in 100,000 November 4, and to 3.31 parts November 11. The iron in the effluent at once disappeared upon the admission of air to the filter, but the turbidity increased, owing to the more rapid flow.

The following average analyses give an idea of the action of the filter. The first analysis is of the effluent from five feet of the fine sand used in filter No. 9A; the second is the effluent from two inches of the same sand supported by nearly five feet of fine gravel; while the last is the effluent from the gravel by itself. The rates of filtration were substantially the same in each case.

[Parts per 100,000.]

	Fine Sand alone.	Fine Sand above Gravel.	Gravel alone.
Month,	September.	September.	November.
Average rate of filtration,	89,000	85,700	80,000
Color,	.12	1.95	.60
Odor,	None.	Decided.	Very slight.
Free ammonia,	.0037	1.1620	.7375
Albuminoid ammonia,	.0154	.0676	.1030
Nitrogen as nitrates,	2.2140	.1940	1.9850
Nitrogen as nitrites,	.0002	.0380	.0343
Oxygen consumed,	.16	.67	.71
Bacteria per cubic centimeter,	1,128	52,180	63,350

We have thus found that with a coarse material above a fine one in the same filter there is a chance of trouble from a clogging of the surface of the fine material below the coarse; and this is far worse than surface clogging, for the latter can be completely remedied by disturbing the surface or by scraping. We have also found that a fine sand supported by a coarse sand will keep its lower layer saturated and act as a water seal, allowing the passage of water but not of air, and may in this way prevent the necessary circulation

of air, and reduce the action of the filter to a mere straining. Thus the possibility exists that different materials which by themselves may be suitable for the purification of sewage by intermittent filtration may be so combined in a filter that oxidation is rendered imperfect or impossible.

The above examples are perhaps extreme cases; with less marked differences in the sand sizes, or with gradual instead of abrupt transition from coarse to fine, the causes of failure might be reduced, or even in some cases entirely eliminated. In the many cases where the fields available for sewage filtration contain layers of various materials, the different sands must be separately studied, in order to determine the probable action of existing combinations; and, in case the natural conditions are unfavorable, changes may be made which will improve the action of the filter.

Filtration of Sewage containing Dye Stuffs.

The sewage ordinarily used at the experiment station is quite free from dye stuffs; only on two or three occasions in five years has a sewage colored to any considerable extent been observed. An attempt was made to get colored sewage from one of the city sewers into which one of the largest of the Lawrence mills was pouring its refuse. A man stood in the outlet of the sewer during working hours, and took frequent samples of the sewage. The result was a surprise, — only one-seventh of the samples showed any color other than that of ordinary house sewage, and the samples reported as colored were of so light a tint as to hardly attract attention, and in each case the color disappeared within one or two days, as the samples were kept in the laboratory.

The dyes used in the mills are comparatively expensive, and are in general economically used, the object being to put the maximum amount of dye on the cloths and the minimum in the sewer. In this case apparently the amount of dye unavoidably wasted was too small to color to any considerable extent the sewage from that section of the city.

It of course frequently happens under other conditions that highly colored sewage is produced, and in order to experiment upon such sewage samples of some of the dyes regularly used in the mills were secured, and weighed quantities of these were added to the doses of

sewage for some of our filters, the amount added being in each case, with the exception of one of the later experiments, enough to strongly color the sewage, even when seen in a small bulk, the idea being to give the filters a far more severe test than filters taking an ordinary mixed city sewage would be likely to receive.

The quantities of the various dyes applied are shown in full in the following table: —

COLOR.	Filter No.	Date of First Application.	Gallons of Colored Sewage Applied per Acre.	Parts of Dye in 100,000.	Pounds of Dye per Million Gallons of Sewage.	Pounds of Dye per Acre.	Color of Resulting Effluent.
Indigo extract,	31	June 24,	614,000	26.40	2,200	1,350	No color.
Logwood extract,	31	July 25,	502,000	13.20	1,100	552	No color.
Alizarine paste,	14	Dec. 12,	960,000	3.30	275	264	No color.
Archil B,	30	Dec. 12,	335,000	6.60	550	183	No color.
Rose azurine,	14	Dec. 19,	960,000	.66	55	52	No color.
Benzo azurine,	14	Dec. 26,	960,000	.66	55	52	No color.
Methylene blue,	14	Dec. 2,	1,280,000	.33	27	35	No color.
Orange 2 R,	30	Dec. 2,	446,000	.66	55	24	No color.
Diamine violet,	19	Dec. 26,	360,000	.66	55	20	*
Magenta,	31	July 11,	335,000	.66	55	18	No color.
Malachite green,	31	July 18,	335,000	.66	55	18	No color.
Naphthylamine black,	30	Dec. 26,	335,000	.66	55	18	*
Scarlet 2 R,	31	Aug. 4,	56,000	1.32	110	6	Colored.
Scarlet 2 R,	31	Aug. 4,	1,076,000	1.32	110	116	†
Scarlet 2 R,	19	Dec. 1,	720,000	.04	4	3	No color.
Scarlet 2 R,	19	Dec. 19,	360,000	.44	37	13	Slight color.
			112,000	.66	55	6	Slight color.
Patent blue,	31	Dec. 12,	335,000	.66	55	18	Strong color.
			56,000	.66	55	3	Slight color.
Patent blue,	28	Dec. 19,	335,000	.66	55	18	Strong color.
Patent blue,	14	Jan. 2, 1893,	160,000	.33	27	4	Slight color.
Patent blue,	14		960,000	.33	27	26	Strong color.

* Very slight color, practically colorless. † Effluent as highly colored as applied sewage.

The filters employed for these experiments were fully described in the Twenty-third Annual Report for 1891. The tables of analyses for the time covered by these experiments will be given in subsequent pages of this report.

Their filling, rates, etc., were as follows: —

Filter Number	Rate of Filtration. — Gallons per Acre Daily.	Number of Doses per Week.	Effective Size in Millimeters of Sand Grain, 10 per Cent. finer than —	Depth of Filter. — Inches.	Date of First Starting of Filter.
14, ...	137,000	6	.48	60	Feb., 1888.
19, ...	51,400	3	.17	60	Feb., 1890.
28, ...	48,000	6	.17	30	April, 1890.
30, ...	48,000	6	.48	30	May, 1890.
31, ...	48,000	6	.17	30	May, 1890.

The first four colors in the table, indigo extract, logwood extract, alizarine paste and archil B, are comparatively dilute colors. All the others are coal-tar colors in extremely concentrated form, and the quantities used were sufficient in every case, with the exception of the second experiment with scarlet 2R, to give the sewage a high color. In most of the experiments the removal of color was complete; the effluents when seen in tubes of 200 or 600 millimeters depth showed only their usual colors. With a few of the colors toward the end of the experiments the effluents, when seen in this way, showed a marked change in tint, but nothing which could be called a color. In the cases of diamine violet and naphthylamine black these tints became marked as seen in the long tubes, but were still too slight to be noticeable when seen under ordinary conditions, and so the effluent was recorded as practically colorless.

On applying scarlet 2R to Filter No. 31 the effluent became strongly colored on the first day following the dose, and on continuing the dose of color the effluent soon became as deeply colored as the applied sewage. After discontinuing the colored dose the effluent continued to be colored in decreasing measure for three months, after which the color was not appreciable. Afterward a smaller quantity of the color was applied to Filter No. 19, which contained twice as deep a layer of the same sand as that in No. 31, with the result that none passed; but with a larger quantity applied the effluent became slightly tinted at the end of the experiment, and would probably have become colored had the dose been longer continued. I am told by Mr. Livermore, chemist of the Washington mills, that this is a cheap color used in wool dyeing, and that it is rapidly and completely taken from the bath by the wool, so that it would not be likely to be discharged into the sewers.

In the experiments with patent blue, which is a new and expensive dye for wool, the color passed through the filter in each case. It was first applied to Filter No. 31, which was in good nitrifying condition, then to No. 28, which was not doing so good work, owing to clogging of the surface, and afterward in reduced quantity to No. 14. The first effluent in each case was not colored, then a slightly colored effluent was obtained, and, as the experiment continued, the color came through freely.

In addition to the above experiments, observations have been taken at the sewage disposal works at South Framingham, where the dye liquors from a large straw shop are discharged with the sewage, and the sewage is frequently if not generally colored by the dyes. The effluents of this sewage after filtration have frequently been examined, and not the slightest trace of color from the dyestuff has ever been found in them.

We may safely conclude that in the purification of sewage from cities or towns by intermittent filtration the presence of any ordinary amount of waste dyestuffs from mills will not unfavorably affect the results, and the filters can be depended upon to remove all such colors. In case, however, the dyestuffs are present in very unusual quantity, as for instance, if the waste liquors of a mill, practically free from sewage, should be by themselves put on a small area at a high rate of filtration, then the filter might or might not remove the color, according to the nature of the dyes used, the amount and character of the filtering material, and other conditions.

Construction of Sewage Carriers.

There is one point in regard to the construction of sewage carriers which has often been mentioned, but which I think will still bear discussion. All carriers for sewage should be so made that when a bed has been flooded and the sewage turned in another direction every particle of sewage should drain out of the carrier, otherwise it will collect in pools where it will putrefy and give off very offensive odors. For the same reason the area of the bed immediately about the outlets of the carriers might with advantage be slightly higher than the rest of the surface. With clean sand there would be an advantage in distribution by allowing a slight slope from the outlets in all directions to the most distant parts of the filter; but I am

inclined to think that if the total difference in level of the different portions of the filter exceeded a few inches, there would be too great a tendency to form ponds in the low places, when the surface became clogged, and particularly in severe winter weather.

Purification of Sewage in Winter.

During the past winter, 1892–93, frequent visits have been made to the three places in this State having large filters, namely, Marlborough, Framingham and Gardner, and the observations so obtained have thrown much light upon some practical points.

The three places differ both in the quality of the sand used for filtration and in the temperature of the sewage. The observations upon both points are less complete than could be desired, but they probably represent the facts with a fair degree of accuracy.

	Effective Size in Millimeters of Sand Grain, 10 Per Cent Finer than—	Ordinary Minimum Temperature of Winter Sewage — Degrees Fahr.
Framingham,	.32 to .42	48 to 50
Marlborough,	.12 to .14	39 to 42
Gardner,	.10 to .24	32 to 38

The temperature of the air has been unusually low, as is shown by the following mean temperature of the winter months for several years, obtained by averaging the mean maximum and mean minimum temperatures for each day, as observed by the Essex Company at Lawrence:—

	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	1891-92.	1892-93.
	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees	Degrees.
December,	-	29.09	24.42	28.21	29.87	33.45	21.07	36.88	26.11
January,	23.85	23.09	20.30	15.46	31.38	28.68	26.74	25.01	16.80
February,	18.82	23.08	25.02	23.63	22.28	30.14	28.57	26.05	23.73
Average,	-	25.09	23.25	22.43	27.84	30.76	25.46	29.31	22.21

The average temperature of December, January and February, taken together, is lower than it has been any year since the experi-

ments at Lawrence were begun, although the first winter at the Experiment Station, that of 1887–88, was almost as cold.

At Gardner, with only a limited filtration area, and with its sewage chilled nearly or quite to the freezing point before reaching the beds, and of course at times put directly into snow, the filters have become badly frozen, and have refused to perform their work. At Framingham and Marlborough, with warmer sewage, the results have been more favorable; the beds have regularly taken all the sewage and have yielded well-purified effluents. A few beds at Marlborough have indeed become frozen and disabled; but with the ample area provided the loss of a couple of beds is not serious; they can be allowed to wait for a thaw, while other beds continue to do the work.

The action of a bed in winter is something like this: During the period when it is out of use it becomes frozen to a greater or less depth, but the frozen sand is ordinarily porous. It appears to be hard and solid, but there are numerous open spaces and channels which allow the entrance of sewage. On top of the frost there may be snow or ice, — the last frozen portion of the previous dose of sewage, which was solidified on the surface before it had time to disappear. When sewage is applied having, as at Framingham and Marlborough, a temperature which enables it to melt ice, it rapidly removes the snow and ice in the immediate vicinity of the place where it enters, and at the same time becomes chilled to the freezing point. If this cold sewage should enter into the sand pores it would be unable to enlarge the passages; but it does not have time to stop for that, — it is pushed rapidly forward to other parts of the filter by fresh warm sewage, which is able to penetrate the sand and remove from it the frost. In this way a portion of the filter becomes thoroughly thawed, and through this portion much of the sewage finds its way; and after sewage is no longer applied, some of the sewage which went to the rest of the filter after being chilled may drain back, and is of course able to pass the now unfrozen sand. If the weather is not too cold, nearly all of the applied sewage may in this way disappear; but with zero weather a portion of the chilled sewage solidifies and adds itself to the pile of ice on the back part of the bed. In case the weather is extremely cold and windy, and if the bed is clogged so that the sewage does not disappear rapidly, the last of the sewage may freeze solidly above

saturated sand, which will then freeze without pores, and become impervious. At Lawrence, when filters have in this way become disabled, they have often been put in operation again by picking a limited number of holes into the frost until a porous layer is reached. This proceeding, however, would be very costly on a large scale, and with ample filtering area is unnecessary, as the frozen areas can be allowed to wait for a thaw while other filters are put in service.

It seems quite probable that with the very large single doses applied at long intervals at Framingham and Marlborough there is less danger from freezing than would be the case with more frequent small doses. A 500,000 gallon dose might take the frost entirely out of a bed and pass through, while a 100,000 gallon dose would be unable to melt enough ice to make for itself a way through the sand, but would solidify upon the surface and close the filter.

The results at Framingham and Marlborough demonstrate that with a sufficient area of porous material and with not too cold sewage intermittent filtration can be successfully carried on in very severe winter weather, although with less complete purification of the sewage than at other times. With colder sewage, however, and only limited area, the problem becomes very difficult, and the present data are inadequate for satisfactory discussion.

On the Area of Filters which it is desirable to provide.

Taking the table on page 437 of the annual report for 1891 as a basis, it is possible, after a proper examination, to give an approximate estimate of the power of any ordinary sand to purify sewage under conditions strictly comparable to the experiments upon which the table was based. Some of these conditions, however, differ from those of actual practice, and necessitate allowances.

The quantity of sewage applied to the experimental filters would be constant from day to day, while city sewage would of course vary in quantity with the weather, although not to so great an extent with a separate system of sewers. It is evident that filters should be provided for the maximum rather than for the average sewage flow; but, on the other hand, a filter in good condition should be able to take much more sewage for a single day than it would be safe to apply every day, and so the increased size of filters would

not need to be as great as the ratio of the maximum to the average daily flow.

In severe winter weather, under ordinary conditions, it seems inevitable that filters will occasionally become disabled by frost, and, although such a filter can be put in operation by the free use of a pick, making holes to the porous material, it would be much cheaper and more satisfactory in every way to have enough area so that in such cases the frozen bed could be allowed to remain unused until the next thaw. It would probably never happen that a large flow of sewage would occur in severely cold weather, and so the extra provision for storm flow may also serve as a reserve for cold weather.

Beds will also at times become clogged and require to be treated in some way before applying more sewage; and, as it may not be always convenient to attend to such matters at short notice, it is desirable to have extra area which will allow the treatment to be undertaken at a convenient time. From every point of view, then, and entirely aside from the important question of a factor of safety, it seems desirable, even necessary, to have the filtering area larger than is indicated by the Lawrence experiments. These experiments should be taken to indicate the theoretical rather than the practical limits of the process. They afford a convenient, and, when used in the proper way, a reliable, basis for estimates; but the figures should not be used to represent the possible average yearly work of a large plant.

Removal of Clogged Sand.

A statement of some of the results upon the removal of clogged sand was given in the Twenty-third Annual Report for 1891, p. 454. There are, however, several considerations not there mentioned, which may affect considerably the practical results. As was shown in the report for 1891, the clogging of the sand is directly proportional to the amount of suspended matter in the applied sewage. The Lawrence sewage is taken only from a thickly settled portion of the city, and only day sewage is pumped. The sewage used is therefore probably much more concentrated than the average for the entire city for twenty-four hours, or than the ordinary average sewage of other moderate-sized cities. On the other hand, a portion of the suspended matter, which may be roughly estimated at twenty per cent., is removed by sedimentation before reaching the filters. All things considered, it seems probable that the sewage as used has quite as much clogging power as the average city sewage as it is in the sewer;

and when such sewage is applied to actual filters the Lawrence figures can be used with confidence as far as strength of sewage is concerned. Some sewage works, however, allow the sewage to deposit some of its sludge before applying it to the beds, and in this case the clogging power would be correspondingly reduced.

As shown above, there are several reasons for not attempting, in practice (at least when it can be avoided), to apply as large average doses of sewage as have been treated on corresponding materials at the Experiment Station. With smaller doses of sewage and a larger excess of air it is believed that the percentage of the organic matter of the sewage stored will be smaller than with larger doses, which permit of more rapid work and require a nicer adjustment of air and organic matters. How great the difference may be must be settled by further experiment. Again, at lower rates of application the quantities of matter which can be stored in the sand without crippling the filters are much greater than at higher rates, where all the open space is required for circulation of air, and any clogging means reduced ventilation. And, further, as was suggested under the heading of "Stratification," the excellent work of a filter composed entirely of sand removed from Filter No. 6 because it was clogged, shows that the conditions in the experimental filters have not been the most favorable possible, and that with other arrangement of the various materials, such perhaps as would be effected by deep ploughing, leaving the clogged sand irregularly distributed to a considerable depth, may allow us to secure good work with more clogging material present than the earlier experiments indicated.

While it must be admitted that the subject is by no means exhausted, the indications point to a much slower clogging of actual filters, run at moderate rates, than has been observed in the experimental filters pushed to their full capacity.

Work of the Filters for 1892.

The filters used during the past year for sewage purification have been mainly the same ones fully described in the "Special Report upon the Purification of Sewage and Water, 1890," and in the Twenty-third Annual Report for the year 1891. Some filters have been refilled, as will be described under their respective heads. For convenience, some of the facts in regard to the material of the filters are given together in the following table : —

Fillings of Sewage Filters in 1892.

Number of Filter.	Dimensions of Filters. Depth of Sand. Inches.	Mean Diameter. Inches.	Area in Fractions of an Acre.	Size of Sand. Effective Size in Millimeters, 10 Per Cent. Finer than —	Uniformity Coefficient.	Manner of Filling.	Remarks. Condition of Sand.
1, . .	63	200	1/200	.48	2.4	Wet.†	- -
2, . .	60	200	1/200	.08*	2.0	Wet.	Known to be stratified. Contains a trench originally filled with coarse sand, but the sands are now mixed.
3A, . .	60	200	1/200	.48 .08*	2.4 2.0	Dry. Dry. Wet.	Thirty inches of coarse above thirty inches of fine sand.
4, . .	60	200	1/200	.04*	2.7	Wet.	Known to be stratified. Contains a trench filled with coarse sand, which is in good order.
5A, . .	63	200	1/200	1.40	2.4	Dry.	Has been for a part of the year covered with fine sand.
6, . .	44	200	1/200	.35	7.8	Wet.	- -
7, . .	60	200	1/200	.35	7.8	Wet.	Covered with loam and soil; sewage applied in drain pipe beneath the surface.
9A, . .	60	200	1/200	.17	2.0	Wet.	Refilled dry during the year.
11A, . .	60	20	1/20,000	.35	7.8	Dry.	Filled with dirty sand removed from Filter No. 6.
12A, . .	60	20	1/20,000	.19	2.0	Dry.	- -
13, . .	63	20	1/20,000	.48	2.4	Wet.	Used only for experiments upon nitrification.
14, . .	63	20	1/20,000	.48	2.4	Wet.	- -
15B, . .	65	20	1/20,000	5.10	2.0	Dry.	- -
16B, . .	65	20	1/20,000	5.10	2.0	Dry.	- -
17A, . .	60	20	1/20,000	.17	.20	Wet.	Layers of marble dust.
19, . .	60	20	1/20,000	.17	.20	Wet.	- -
25, . .	120	20	1/20,000	-	-	Wet.	Filled with loam and soil.
26, . .	30	17	1/27,900	9.00	1.5	Dry.	- -
27, . .	30	17	1/27,900	.48	2.4	Dry.	- -
28, . .	30	17	1/27,900	.17	2.0	Dry.	- -
29, . .	30	17	1/27,900	9.00	1.5	Dry.	- -
30, . .	30	17	1/27,900	.48	2.4	Dry.	- -
31, . .	30	17	1/27,900	.17	2.0	Dry.	- -
32, . .	30	17	1/27,900	.17	2.0	Dry.	- -

* These figures were obtained from new measurements, and differ slightly from those previously given.

† By wet is meant that the sand was thrown into water.

Measurement of Sewage.

In October it was discovered that the basins used for the measurement of the applied sewage had settled, owing to the rotting of the posts on which they rested, and that considerable errors in the measurement were being made. The basins were at once raised to a level and put upon substantial foundations, and the errors in the

measurement of the quantities of sewage which had been applied were carefully determined. It was of course impossible to tell exactly how long the settling had been taking place, but a study of the quantities applied, in connection with the quantities of the effluent and of the rainfall for the different months showed clearly that the errors for the first months of 1892 were not more than one-half as large as the observed errors in October. Considering the different filters flooded from the same sewage basin together, the most reasonable results were obtained by assuming for the upper basins one-half the error for the first half of the year, January to June, 1892, and the whole error from July to the time when the basins were levelled; and for the lower basin one-third the error for January to March, one-half from April to June, and afterward the whole error. Using these corrections, a table has been prepared showing the quantity of sewage applied to each of the filters affected by these measurements, and these figures are believed to be a close approximation to the facts. The quantity of water filtered through Filter No. 8 has also been calculated. For this purpose the measurements of effluent were taken, as far as the results were satisfactory, and during the seven months, when, owing to leakage in the effluent basin, these measurements were lacking or unsatisfactory, estimates based upon the quantity of water applied have been substituted for them. The results are as follows: —

Corrected Quantities of Sewage for each Month, in Gallons.

Month — 1892.	Applied to Tank 1.	Applied to Tank 2.	Applied to Tank 3.	Applied to Tank 4.	Applied to Tank 5.	Applied to Tank 6.	Applied to Tank 7.	Passed through Tank 8.	Applied to Tank 9.
January,	16,432	3,096	8,216	6,708	13,176	3,353	2,739	12,821	3,139
February,	15,484	2,580	7,900	6,157	14,128	2,347	2,633	17,605	3,139
March,	17,064	1,660	8,532	7,224	14,684	1,218	2,844	22,661	2,074
April,	15,800	2,158	8,216	6,192	14,188	5,904	2,548	19,579	4,114
May,	16,432	2,158	8,216	4,044	7,272	3,608	2,548	19,131	4,029
June,	15,168	2,950	8,116	5,408	12,942	8,528	2,518	23,971	15,028
July,	16,932	3,300	8,632	2,160	12,420	7,956	1,900	26,563	13,900
August,	17,264	3,564	8,964	4,752	13,320	7,956	228	33,641	15,012
September,	17,264	4,572	8,632	5,616	12,852	7,650	0	28,042	13,344
October,	16,600	5,948	7,968	5,184	6,038	7,956	3,120	20,847	7,228
November,	15,300	4,000	7,500	5,200	12,000	9,100	5,200	17,744	13,200
December,	15,300	2,400	6,600	5,200	14,800	8,050	5,200	14,594	12,600
Totals,	195,040	38,386	97,492	63,845	147,820	73,626	31,478	257,199	106,807

Corrected Quantities of Sewage for each Month, in Gallons per Acre per Day.

MONTH — 1892.	Applied to Tank 1.	Applied to Tank 2.	Applied to Tank 3.	Applied to Tank 4.	Applied to Tank 5.	Applied to Tank 6.	Applied to Tank 7.	Passed through Tank 8.	Applied to Tank 9.
January,	106,000	20,000	53,000	43,300	85,000	21,600	17,700	82,700	20,300
February,	106,800	17,800	54,500	42,500	97,400	16,200	18,200	121,400	21,600
March,	110,100	10,700	55,000	46,600	94,700	7,900	18,300	146,200	13,400
April,	105,300	14,400	54,800	41,300	94,600	39,400	17,000	130,500	27,400
May,	106,000	13,900	53,000	26,100	46,900	23,300	16,400	123,400	26,000
June,	101,100	19,700	54,100	36,000	86,200	56,800	16,800	159,800	100,200
July,	109,200	21,300	55,700	13,900	80,100	51,300	12,300	171,400	89,700
August,	111,300	23,000	57,800	30,700	85,900	51,300	1,500	217,000	96,800
September,	115,100	30,500	57,500	37,400	85,700	51,000	0	186,900	89,000
October,	107,100	38,400	51,400	33,400	38,900	51,300	20,100	134,500	46,600
November,	102,000	26,700	50,000	34,700	80,000	60,700	34,700	118,300	88,000
December,	98,700	15,500	42,600	33,500	95,500	51,900	33,500	94,200	81,300
Totals,	1,278,700	251,900	639,400	419,400	970,900	482,700	206,500	1,686,300	700,300
Averages,	106,600	21,000	53,300	34,900	80,900	40,200	17,200	140,500	58,400

FILTER TANK NO. 1.

At the beginning of 1892 Filter No. 1 was considerably clogged by the organic matters stored from the sewage filtered during four years. During this time nothing had been removed from the surface of the filter, although sewage equivalent to a column more than three hundred feet deep and the diameter of the filter had been treated. The surface was made into ridges and trenches, and the surfaces of the trenches were from time to time scraped on to the ridges to relieve the clogging. The surface was not protected from the weather, and sewage was regularly applied at a rate slightly above 100,000 gallons per acre daily. The winter (1891–1892) was not so cold as either the preceding or following ones, and the effect of cold upon the effluent was less, in spite of the clogging. During January over ninety per cent. of the organic matters of the applied sewage were removed, while filtering 106,000 gallons per acre daily, and the free ammonia was only .2960 part per 100,000. The filter was covered by canvas from February 11 to April 1. During February the effluent deteriorated somewhat in quality but improved again in March. In April the clogging became so serious that only very imperfect nitrification was obtained, and this condition continued until June 2, when the dirty sand to a depth of five inches was removed. This at once restored to the

filter its old-time power of purification, and excellent results were obtained in the following months. In October poor work was done for a few days, caused by a surface accumulation of slimy matter, which was broken by raking two inches deep October 18, and good results were again obtained until the last of December, when the unfavorable effect of extremely cold weather was felt.

The average work of the filter during the year is shown by the following table: —

Effluent from Filter Tank No. 1.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	106,000	45°	39°	4h. 45m.	3	V.sl.	.20	.2960	.0671	6.55	1.4378	.0220	.45	25,789
February, .	106,800	45°	36°	6h.	3½	V.sl.	.30	.6587	.1062	7.51	.9900	.0310	.68	33,750
March, .	110,100	45°	38°	3h. 50m.	1¼	V.sl.	.22	.1133	.0594	8.09	1.6033	.0258	.38	18,495
April, .	105,300	47°	47°	1h. 55m.	0	Slight	.37	.5171	.1121	7.72	.7455	.0152	.76	81,667
May, . .	106,000	54°	55°	1h. 6m.	0	V.sl.	.44	.6356	.1002	7.55	.7144	.0040	.65	76,444
June, . .	101,100	69°	72°	0	0	V.sl.	.33	.1788	.0592	9.21	2.1575	.0080	.43	25,862
July, . .	109,200	72°	75°	19m.	0	V.sl.	.23	.0399	.0435	10.13	2.5000	.0110	.31	34,243
August, .	111,300	72°	76°	0	0	V.sl.	.33	.0624	.0569	9.26	1.7720	.0073	.41	88,000
September,	115,100	65°	64°	13m.	0	V.sl.	.36	.0904	.0436	9.36	1.8900	.0462	.47	66,800
October, .	107,100	54°	57°	1h. 13m.	0	Slight	.41	.5300	.0885	10.88	1.4900	.0488	.69	96,500
November,	102,000	44°	47°	1h. 5m.	2	V.sl.	.33	.0604	.0389	6.45	1.4500	.0148	.36	49,550
December,	98,700	46°	39°	50m.	2¾	V.sl.	.37	.5280	.1328	7.18	1.5340	.0200	.88	74,800

Sewage applied twelve times a week. Surface protected by canvas cover from February 11 to April 1. Surface of trenches raked (or picked) about 1 inch deep each week. Surface raked (or picked) 2 to 3 inches deep, January 4, 11, February 8, 24, April 29, October 18, November 28. Sand scraped from trenches, ½ inch, April 4; ½ inch, April 8; ½ inch, April 12; 1 inch, April 18; 1 inch, April 25; 2 inches, May 16. June 2, 5 inches of sand removed and surface levelled. Snow and ice removed January 7, 9, 11, 15, 20, February 3, 11, November 30, December 23, 24.

Filter Tank No. 2.

The surface of this filter was quite badly clogged at the beginning of 1892, and in order to keep it in operation during the cold weather it was necessary to protect the surface with a canvas cover, which remained over the filter until April 1. Even then the quantity of sewage which could be purified was steadily decreasing, only 10,700 gallons per acre daily being applied in March. The surface of the ridges and trenches on the filter was several times disturbed, but without beneficial result; and on May 31 the surface was levelled and

planted, one-half with rye and one-half with orchard grass, and the dose of sewage changed to 20,000 gallons per acre six times a week, the object being to favor the growth of the grass. The grass grew rapidly, being about six inches high by July 5 and two feet high by August 1; but it was neither rye nor orchard grass, but a coarse pigeon grass over the whole area. The effluent was meanwhile steadily improving in quality, and became extremely well purified during the last three months of the year, nor did it deteriorate in the least when the quantity of sewage applied was doubled in September.

The surface of this filter has been worked over to such an extent that the ring of coarse sand placed in it in 1888 has become so mixed with the fine sand as to be without appreciable effect, and the filter is practically all fine sand. Sand samples have shown that there is distinct stratification in the filter, and a lack of certain knowledge as to how much of the poor work may have been due to this cause and how much to surface clogging detracts somewhat from the value of the results. The average work by months for the year is shown in the following table: —

Effluent from Filter Tank No. 2.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	20,000	44°	41°	24h.	4	V. sl.	.15	.0530	.0212	6.99	.1800	.0015	.24	28
February,	17,800	44°	38°	24h.	0	V. sl.	.19	.3475	.0290	3.74	.2450	.0002	.25	1
March,	10,700	44°	36°	15h.	1	V. sl.	.30	.6950	.0315	5.41	.1750	.0010	.24	20
April,	14,400	47°	44°	16h.	0	Dec.	red.	.9520	.0572	4.52	.0480	.0036	.58	14
May,	13,900	54°	51°	16h. 30m.	0	V. sl.	.82	1.6100	.0465	11.31	.4675	.0041	.33	20
June,	19,700	69°	64°	4h. 6m.	0	None	.13	1.6350	.0480	8.02	1.9075	.0086	.32	13
July,	21,300	72°	69°	5h. 8m.	0	"	.11	1.0740	.0404	7.83	2.5360	.0270	.27	47
August,	23,000	73°	71°	2h. 4m.	0	"	.10	.5000	.0255	10.78	2.0350	.0235	.22	48
September,	30,500	65°	66°	8h. 15m.	0	"	.11	.0531	.0137	14.28	3.1240	.0131	.14	53
October,	38,400	54°	60°	15h.	0	"	.06	.0008	.0097	8.40	2.7400	.0001	.07	103
November,	26,700	42°	50°	24h.	0	"	.06	.0007	.0083	6.73	2.2975	.0000	.06	24
December,	15,500	45°	43°	24h.	2	"	.09	.0005	.0089	5.34	1.5780	.0007	.09	8

Sewage applied six times in January, five times in February, three times a week in March, April and May, six times a week until September 17, and afterwards three times a week. Surface protected by canvas cover from January 6 to April 1, and after November 29. Surface of trenches raked about 1 inch deep each week from March 7 to May 30. Surface levelled May 31. Two inches of sand removed from trenches April 11. Grass on surface cut September 13. Ice removed from surface January 6 and March 7.

Filter Tank No. 3A.

This filter has received sewage during 1892 at an almost uniform rate of 53,000 gallons per acre daily, and with very satisfactory results, the highest albuminoid ammonia during the year, that of February, being only .0420 part in 100,000. In January, with no protection from the weather, the results were particularly good, although the free ammonia was increasing. On February 11 the filter was protected by a canvas cover, which was removed April 1. There was no immediate improvement after covering, but in the following month higher nitrification was obtained. In October the surface began to become clogged, and it was disturbed two inches deep, after which no further trouble was experienced.

The average results for the year by months are as follows: —

Effluent from Filter Tank No 3A.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	53,000	45°	40°	45m.	4½	None.	.04	.0862	.0160	6.27	1.5520	.0047	.13	77
February, .	54,500	45°	37°	1h. 43m.	4	"	.07	.6000	.0420	11.64	1.1325	.0035	.26	19
March, .	55,000	44°	36°	-	1¼	"	.06	.4550	.0270	9.30	2.0625	.0068	.24	17
April, .	54,800	48°	47°	15m.	0	"	.04	.0537	.0196	7.47	3.6480	.0013	.18	22
May, . .	53,000	54°	55°	-	0	"	.07	.0099	.0128	8.75	3.4175	.0000	.24	11
June, . .	54,100	70°	67°	20m.	0	"	.06	.0111	.0151	8.36	3.9050	.0005	.21	14
July, . .	55,700	73°	73°	35m.	0	"	.07	.0279	.0177	11.10	3.5740	.0118	.20	30
August, .	57,800	73°	75°	41m.	0	"	.10	.0099	.0162	8.13	2.9475	.0027	.17	819
September,	57,500	65°	68°	1h. 6m.	0	"	.09	.0025	.0131	8.65	2.8260	.0001	.13	525
October, .	51,400	55°	60°	6h. 15m.	0	"	.08	.0131	.0142	9.41	2.8925	.0005	.11	766
November,	50,000	43°	50°	3h. 28m.	3	"	.06	.0921	.0138	6.29	2.6450	.0006	.17	105
December,	42,600	45°	42°	6h.	2½	"	.12	.3060	.0196	7.45	1.7440	.0016	.21	144

Sewage applied six times a week. Surface protected by canvas cover from February 11 to April 1. Surface raked about 1 inch deep each week until May 30. Upper 2 inches of sand turned over October 19. Snow and ice removed January 7, 9, 11, 16, 20, 30, February 3, 11, November 30, December 23.

Filter Tank No. 4.

At the beginning of 1892 this filter was receiving sewage at a rate of over 40,000 gallons per acre daily, and with excellent results, although exposed, without protection, to the winter weather. The sewage passed freely, and as far as could be determined the filter

was holding its own in every way, the analyses early in February being quite as good as those of January or December, 1891. From February 11 to April 1 the trench of coarse sand was covered with boards and sewage applied beneath this cover. The deterioration which followed can hardly be attributed to the change, but was caused, as was shown by a thorough investigation in August, by a clogging of the fine sand (of which the bulk of the filter is composed) at the point of junction with the coarse sand in the trench. From March to August only poor results were obtained; but after the coarse sand was removed and replaced, after disturbing the fine sand, the clogging disappeared, and the effluent rapidly improved in quality.

The sand below the trench of coarse sand was examined, and found to contain well-defined stratified layers; but as yet we have no clear evidence that these layers have injuriously affected the action of the filter.

The operation of the filter for 1892 is shown by the following table of monthly averages: —

Effluent from Filter Tank No. 4.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	43,300	44°	41°	16h.	1	None.	.07	.0156	.0136	5.63	.9800	.0002	.18	1
February, .	42,500	44°	38°	12h.	1	"	.08	.0153	.0172	6.87	.5500	.0004	.20	34
March, .	46,600	44°	36°	12h.	2	V. sl.	.20	.1452	.0438	6.27	.0840	.0010	.47	377
April, .	41,300	47°	44°	24h.	0	V. sl	.38	.5950	.0820	6.21	.1525	.0013	.72	49
May, .	26,100	54°	52°	–	0	V. sl.	2.09	.8450	.0980	7.01	.0750	.0017	1.05	30
June, .	36,000	69°	62°	–	0	V. sl.	5.20	1.0100	.1012	6.37	.0580	.0021	1.64	36
July, . .	13,900	69°	70°	24h.	0	V. sl.	6.23	1.1600	.0980	6.58	.0167	.0018	2.07	14
August, .	30,700	73°	70°	1h. 50m.	0	V. sl.	3.28	1.4067	.0980	8.07	.2967	.0067	1.61	492
September,	37,400	65°	68°	2h. 45m.	0	V sl.	1.24	.8480	.0516	8.49	1.1500	.0080	.77	29
October, .	33,400	56°	61°	2h.	0	V. sl.	.35	.2040	.0235	8.23	1.5700	.0061	.34	41
November,	34,700	43°	52°	–	2	None	.17	.0243	.0128	6.83	2.1375	.0029	.26	16
December,	33,500	45°	45°	9h. 15m.	2¼	"	.13	.0018	.0113	6.87	1.0980	.0000	.21	7

Sewage applied three times a week, except from July 13 to August 5, when no sewage was applied. Sand-ring covered with boards from February 11 to March 30. Surface protected by canvas cover after November 29. Surface of sand-ring raked about 1 inch deep each week.

One-half inch of sand removed from sand-ring April 4 and 1 inch May 9. August 4 coarse sand removed from sand-ring, fine sand disturbed 3 to 4 inches deep, and coarse sand replaced. Grass on surface cut July 27. Snow and ice removed from sand-ring January 7, 9, 12, 16, 21, 23, 28, 30, February 1, 4, 6, 11.

Filter Tank No. 5A.

The most important experiments made with this filter have already been given under the heading "Stratification and the Effect of Horizontal Layers" (page 409). During the first three months of the year, while exposed to winter weather, it gave a fairly well-purified effluent at a rate of over 90,000 gallons per acre daily. Afterward it was covered with layers of finer sands, as described above (page 411), with which more perfect straining but less oxidation was obtained. After the completion of these experiments the fine sand was removed, and the results of November and December show the action of the gravel by itself. The great difficulty of getting good distribution on so coarse a material would prevent its use on a large scale, unless some satisfactory means of distribution could be devised. The monthly averages of results are as follows: —

Effluent from Filter Tank No. 5A.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	85,000	44°	39°	5h. 34m.	6	Slight	.25	.9633	.1080	6.28	.6467	.0030	.66	116,733
February, .	97,400	45°	36°	-	5	Slight	.33	1.5238	.1182	8.18	.6562	.0134	.68	40,696
March, .	94,700	44°	37°	-	3	Slight	.27	.9489	.0887	7.27	1.2433	.0221	.45	33,087
April, .	94,600	47°	49°	1h. 25m.	0	V. sl.	.24	.4062	.1029	7.91	2.7833	.0899	.61	170,444
May, . .	46,900	53°	56°	24h.	0	V. sl.	.60	.4689	.0680	7.93	.2733	.0064	.75	46,478
June, . .	86,200	68°	68°	-	0	V. sl.	.44	.1060	.0720	8.43	3.6275	.0760	.55	172,250
July, . .	80,100	71°	71°	2h. 16m.	0	Slight	.57	.1330	.0664	10.39	1.1329	.0029	.54	12,741
August, .	85,900	72°	74°	4h. 30m.	0	Slight	1.42	.6160	.0760	13.01	.1348	.0005	.80	109,400
September,	85,700	64°	67°	2h. 45m.	0	Slight	1.95	1.1620	.0676	9.65	.1940	.0380	.67	52,180
October, .	38,900	56°	58°	24h.	0	Dec.	2.95	1.7200	.0620	9.11	.0000	.0000	.72	7,712
November,	80,000	44°	49°	30m.	1½	V. sl.	.60	.7375	.1030	8.44	1.9850	.0343	.71	63,350
December,	95,500	44°	41°	-	3½	Slight	.91	.7940	.1828	7.20	.9840	.0352	1.15	364,000

Sewage applied twelve times a week until January 9, afterwards eighteen times a week, except from May 20 to June 2, and from October 19 to November 6, when no sewage was applied. Surface raked about 1 inch deep each week except from April 1 to 30 and from October 4 to November 21. March 29, upper 3 inches removed and replaced in succession by 1 inch of No. 1 (coarse) sand, 1 inch of No. 9 (fine) sand and 1 inch of No. 1 sand. June 2, upper 2 inches removed and replaced with 2 inches of No. 9 sand. The layer of fine sand was removed October 31. November 4, about one inch of coarse sand removed from surface. Snow and ice removed from surface January 7, 9, 15, 20, 30, February 3, 11, 12, March 3, 4, 18, 19, November 30.

Filter Tank No. 6.

Toward the close of 1891 Filter No. 6 became clogged and unable to purify, in a satisfactory manner, its dose of sewage. Protection from the winter weather by a canvas cover, from January 6 to March 29, did not improve its condition, and the quantity which could be applied steadily fell off from its nominal dose of 60,000 gallons per acre daily to 16,000 gallons in February and 8,000 in March. It was supposed at the time that the failure was due to surface clogging; but when the surface was scraped, as described under the heading "Stratification," only a partial relief followed, and it was not until the fine layers, caused by throwing the sand into water when the filters were originally filled, were broken by disturbing the sand 18 inches deep on May 16 that the full purifying power of the filter was restored. Following this treatment very complete purification was obtained during the rest of the year, at an average rate of about 53,000 gallons per acre daily.

Effluent from Filter Tank No. 6.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	21,600	44°	39°	-	1½	V. sl.	.20	1.0100	.0688	6.55	.0280	.0009	.64	1,228
February,	16,200	44°	37°	-	¼	V. sl.	.19	1.4400	.0570	6.68	.0450	.0011	.56	146
March,	7,900	45°	38°	-	1¾	V. sl.	.28	1.6050	.0630	7.29	.0225	.0007	.66	312
April,	39,400	46°	47°	7h. 58m.	0	Sl.	.59	1.7600	.0820	8.10	.0220	.0012	.71	10,307
May,	23,300	55°	55°	-	0	Sl.	1.38	1.8820	.0784	7.61	.7400	.1102	.79	11,416
June,	56,800	69°	69°	0	0	V. sl.	.09	.1440	.0252	9.27	4.2700	.0304	.22	4,412
July,	51,300	72°	73°	31m.	0	None.	.05	.0042	.0152	7.96	3.0280	.0008	.12	841
August,	51,300	72°	74°	16m.	0	"	.06	.0007	.0137	13.60	3.2925	.0006	.08	4,467
September,	51,000	65°	69°	34m.	0	"	.09	.0013	.0123	8.73	2.9140	.0001	.08	2,471
October,	51,300	55°	58°	36m.	0	"	.15	.0191	.0188	9.21	2.4250	.0053	.12	7,200
November,	60,700	46°	48°	4h. 21m.	2	V. sl.	.13	.0295	.0260	7.40	1.5550	.0005	.17	14,675
December,	51,900	44°	41°	1h. 57m.	4	V. sl.	.35	.5708	.0644	8.59	1.1600	.2320	.65	25,460

Sewage applied three times a week till April 10, afterwards six times a week, except no sewage applied from May 4 to May 19. Surface raked about 1 inch deep each week, beginning April 18. Surface raked 1 to 3 inches deep each week in March. Sand turned over 6 inches deep on April 11. Upper 2 inches removed March 29, and replaced April 2 with 2 inches of No. 6 sand. May 19, upper foot of sand removed, the second foot disturbed and first foot then replaced. Snow and ice removed from surface January 2, 6, March 2, November 30, December 23.

Filter Tank No. 7.

Sub-surface Application of Sewage.

During the first seven months of 1892, Filter No. 7 did excellent work with an average dose of over 17,000 gallons per acre daily. It was not injuriously affected by the cold weather of the first months.

In July the free ammonia was increasing and the dose of sewage completely filled the pipes, so that it was occasionally impossible to apply the full dose of sewage at once. This showed a marked change from the earlier conditions, and to determine the cause the drain pipe which received the sewage was dug up. It was found to be nearly filled with sludge from the sewage, the six-inch pipe having a passage for sewage only about two inches high. The joints were also filled to such an extent that sewage passed out with difficulty, and apparently the greater part went through a few places where the joints were more open. After cleaning and replacing the pipes sewage was again applied at a rate of 34,000 gallons per acre daily, but only fair purification was obtained.

Sewage had been applied to the pipes before cleaning for three years, from June 25, 1889, to Aug. 1, 1892, the total quantity being 125,000 gallons, equivalent to 25,000,000 gallons on an acre. The applied sewage (taking the average yearly analyses) contained 5.8 pounds of nitrogen as insoluble albuminoid ammonia, and of this amount 1.28 pounds, or 22 per cent., were found in the pipe at the time of cleaning. The character of the effluents obtained during the year is shown in the following table of monthly averages : —

Effluent from Filter Tank No. 7.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, . .	17,700	45°	42°	None.	.03	.0201	.0091	5.19	.8880	.0002	.08	16
February, . .	18,200	44°	39°	"	.04	.0099	.0087	6.45	.7825	.0000	.11	3
March, . .	18,300	44°	38°	"	.03	.0426	.0099	5.63	.9675	.0036	.11	3
April, . .	17,000	47°	46°	"	.03	.0328	.0099	6.70	2.0880	.0015	.11	7
May, . . .	16,400	54°	53°	"	.02	.0047	.0074	7.92	1.6800	.0001	.09	18
June, . . .	16,800	69°	66°	"	.04	.0042	.0080	8.11	1.7150	.0002	.08	123
July, . . .	12,300	71°	71°	"	.04	.0566	.0094	11.04	2.0860	.0059	.10	13
August, . .	1,500	–	–	–	–	–	–	–	–	–	–	–
September, .	0	–	–	–	–	–	–	–	–	–	–	–
October, . .	20,100	54°	59°	None.	.11	.1003	.0221	9.31	4.4375	.0237	.16	8,875
November, .	34,700	45°	50°	"	.11	.0719	.0161	7.54	1.6700	.0015	.16	10,700
December, .	33,500	44°	43°	V. sl.	.77	.6100	.0356	8.88	.3640	.0226	.39	2,220

Sewage applied six times a week except from August 4 to October 6. On October 7 the pipe through which sewage is applied was taken out, cleaned and replaced.

Filter Tank No. 9 A.

In the latter part of 1891 Filter No. 9 A commenced to give an incompletely nitrified effluent, due evidently to insufficient ventilation. The amount of nitrogenous matter in the surface sand was less than in other filters when they had become clogged, and disturbing the surface and making into ridges and trenches were without permanent beneficial effect. The filter was nevertheless unquestionably clogged, and the quantity of sewage which could be applied fell in March to 13,000 gallons per acre daily. An investigation in May showed that the cause of failure was the presence of numerous stratified layers in the sand, which had become clogged and impervious, as described under the heading "Stratification." The somewhat disturbed surface sand was removed, and the rest of the sand in the filter was shovelled out and then shovelled back without throwing it into water. In this way the layers were thoroughly broken. Following this change sewage was easily taken at the rate of 100,000 gallons per acre daily, with excellent results. The experiment with systematic scraping, already described under that heading, was afterward tried upon this filter, with the general result that, with the high rate of filtration used, more sand needed to be replaced in proportion to the sewage filtered than with the usual treatment of raking and spading up the surface. The information obtained in regard to the scraping will be found on page 407. The monthly averages of analyses of effluents are as follows: —

Effluent from Filter Tank No. 9A.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	20,300	44°	42°	24h.	½	V. sl.	.20	1.0740	.0740	7.19	.3680	.0130	.56	166
February,	21,600	44°	37°	24h.	0	Slight	.78	1.6000	.0615	8.75	.2600	.0045	.50	690
March,	13,400	45°	37°	14h.	2	Gt.	Red	1.5250	.0570	6.90	.1600	.0120	.58	25
April,	27,400	46°	45°	10h.	0	Slight	.62	1.3520	.0584	9.06	.5700	.0056	.41	33
May,	26,000	54°	52°	24h.	0	V. sl.	.56	.9600	.0445	7.23	.7975	.0950	.43	319
June,	100,200	64°	69°	1h. 41m.	0	None.	.06	.0143	.0166	8.21	1.9125	.0061	.15	453
July,	89,700	71°	73°	37m.	0	"	.07	.0022	.0138	11.77	2.0300	.0005	.16	818
August,	96,800	72°	75°	1h. 49m.	0	"	.11	.0111	.0164	11.84	2.4800	.0014	.16	3,011
September,	89,000	64°	68°	3h. 25m.	0	"	.12	.0037	.0154	8.69	2.2140	.0002	.16	1,128
October,	46,600	56°	58°	17h.	0	"	.09	.0029	.0114	7.94	2.7525	.0001	.11	147
November,	88,000	45°	47°	2h. 51m.	2½	"	.08	.2687	.0314	6.81	1.5250	.0018	.35	731
December,	81,300	45°	40°	19h.	3	"	.23	.9500	.0600	7.16	.7800	.0069	.74	21,294

Sewage applied three times a week till May 6, then no sewage applied till May 25, afterwards six times a week, except that no sewage was applied October 20 to 31. Surface protected by canvas cover from February 11 to April 1, and after November 29. Surface of trenches raked about 1 inch deep each week until May 10, when the surface of the filter was levelled. Surface raked about 1 inch deep each week from May 30 to July 18. One inch of sand taken from trenches January 1, 6 inches of sand removed May 10. Scum removed from surface September 9, 45 pounds; September 20, 656 pounds; October 7, 963 pounds; November 9, 990 pounds. Snow and ice removed from surface January 1, 8, 11, 18, 20, 22, 26, 28, 30, February 1, 3, 5, 8, 10, 11, March 4.

Filter Tank No. 11A.

The experiment made in this filter with sand removed from Filter No. 6, because it was clogged with organic matter, was described above (page 403), under the heading "Experiment with Clogged Sand." The filter was started March 30 with the application of city water at the rate of 51,000 gallons per acre daily. The effluent contained large quantities of organic matter, which, however, gradually decreased. From May 10 to June 4 an aspirator was used to change the air in the sand, the result being a very decided improvement in the quality of the effluent, although, even with this artificial ventilation, no nitrification was obtained.

Beginning June 7 sewage was applied in place of the city water, but with very poor results until June 29, when the aspirator was again attached, and improvement at once followed and continued until early in September, when high nitrification was obtained. The aspirator was removed September 25, and there followed temporarily a deterioration in the quality of effluent; but afterward the result improved, and in November and December an effluent was obtained which compared favorably with those from comparatively clean sands.

The results obtained by months are as follows: —

Effluent from Filter Tank No. 11 A.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
April,	52,000	44°	50°	2	Great	Red.	4.9375	.3875	2.49	.0125	.0000	3.47	49,500
May,	46,400	52°	57°	5	Great	4.65	2.2625	.2175	.92	.0400	.0003	1.77	19,950
June,	52,000	66°	69°	4	Great	7.12	4.0000	.3175	5.16	.0450	.0007	2.77	17,525
July,	50,400	70°	72°	4	Dec.	2.05	1.3833	.2307	10.49	.1733	.0033	1.09	12,781
August,	52,200	-	71°	3	Dec	1.50	1.0000	.1330	11.57	.5750	.0060	.77	72,840
September,	52,000	-	64°	4	V. sl.	.38	.5500	.1020	9.09	2.6300	.0090	.62	26,000
October,	50,400	-	56°	4	Slight	1.87	.5100	.1170	8.60	.2800	.0075	.83	34,350
November,	52,000	-	49°	5	V. sl.	.45	.2033	.0687	8.08	1.8233	.0067	.40	28,333
December,	52,200	-	46°	5	Slight	.33	.0810	.0510	7.73	1.7650	.1320	.45	73,500

Filter filled March 30 with sand, clogged by sewage, removed from Filter No. 6. Surface raked about 3 inches deep each week. Air in the sand changed by an aspirator May 10 to June 4, and June 29 to September 25. City water applied six times a week until June 6, and afterwards sewage.

Filter Tanks Nos. 12 A, 15 B and 16 B.

Filter Tank No. 12 A was filled June 20 with five feet of sand having 10 per cent. finer than .19 millimeter, supported by the usual five inches of gravel and coarse sand, all put in position dry, and settled by filling with water from below, as in this way a very compact filling free from stratification is obtained. Filter Tanks Nos. 15 B and 16 B were filled at the same time with screened gravel having 10 per cent. finer than 5.10 millimeters, or approximately the same material as the original No. 16.

During July these three filters were dosed alternately with city water and a solution of salt, in order to determine their water capacities by means of chemical determinations of chlorine in the effluent. The results obtained were as follows: —

Filter No.	Size of Sand. Ten Per Cent. Finer Than—	Amount of Water retained after draining Twenty-four Hours.	Reckoned as Per Cent. of the Total Volume of the Filter.
	Millimeters.	Gallons.	Per Cent.
12A,	0.19	10.9	12.1
15B,	5.10	10.8	12.0
16B,	5.10	11.4	12.7

The result with the .19 millimeter sand agrees with the results of earlier experiments, but the figures for the gravel seem extremely high. The experiment was repeated to such an extent as to show that the figures were substantially correct. It was found, however, in January, 1893, that the outlets of both No. 15 B and No. 16 B had become reduced in size by deposits of matter from the sewage (or by fungoid growth), so that water was dammed up, and stood in the lower part of the filter, and it is not impossible that there may have been some such condition at the time of making these experiments.

On July 25 the three filters were put in operation with sewage; two gallons of sewage were applied to Nos. 15 B and 16 B four times each day, and the effluents from both filters were put upon No. 12 A. The two filters of gravel removed the greater part of the organic matters, and effected partial oxidation, while the sand completed the process, and, in addition, gave the sewage a thorough straining and delivered it quite free from turbidity. The results being

quite favorable, the size of the sewage doses was increased one-half on September 1, which gave the following average rates : —

	Gallons per acre daily.
Filters Nos. 15 B and 16 B, each, ...	206,000
Filter No. 12 A, ...	411,000
Average rate for the combined area of three filters, .	137,000

The average results by months are shown by the following table : —

Effluent from Filter Tanks Nos. 12A, 15B and 16B.

[Parts per 100,000.]

1892.	Tank.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
August, .	15B	139,400	-	70°	-	Sl't.	.50	.5400	.1375	10.49	.5277	.1450	.80	266,000
	16B	139,400	-	70°	-	Sl't.	.48	.5175	.1275	10.19	.4592	.1751	.80	272,000
	12A	272,000	-	71°	3	None	.10	.0433	.0149	9.50	1.2750	.0277	.14	156
September,	15B	208,000	-	63°	-	Sl't.	1.06	.4640	.1720	8.91	.9880	.0666	.92	213,650
	16B	207,400	-	64°	-	Sl't.	.96	.4040	.1516	8.87	.9120	.0712	.90	188,440
	12A	400,000	-	65°	6	None	.11	.0022	.0138	9.52	1.2660	.0001	.15	119
October, .	15B	201,400	-	56°	-	Sl't.	.90	.4450	.1165	7.78	1.0425	.0235	.58	162,500
	16B	201,400	-	56°	-	Sl't.	1.01	.4725	.1125	7.79	.5450	.0102	.59	165,000
	12A	387,200	-	58°	4	None	.11	.0035	.0175	7.72	1.1225	.0001	.16	173
November,	15B	208,000	-	48°	-	Sl't.	.92	.4975	.1030	7.49	.1900	.0065	.64	162,750
	16B	208,000	-	48°	-	Sl't.	1.00	.4675	.1065	7.40	.3800	.0027	.64	164,000
	12A	404,600	-	51°	18	None	.13	.0037	.0196	7.60	1.1350	.0004	.18	875
December,	15B	209,000	-	45°	-	Sl't.	1.56	.6900	.1188	7.01	.0440	.0000	.76	244,000
	16B	209,000	-	44°	-	Sl't.	1.20	.5500	.1064	6.89	.0900	.0028	.68	323,200
	12A	396,800	-	49°	9	None	.14	.0058	.0225	7.69	.7320	.0004	.22	7,436

Sewage applied to Tanks 15B and 16B twenty-four times a week, and their effluents applied to Tank 12A twenty-four times a week. Surface of Tank 12A raked about 3 inches deep December 3, 8, 15, 29.

Filter Tank No. 13.

This filter during 1892 has been used only for the filtration of a solution of ammonia, to determine the effect of nitrification upon the removal of bacteria. The details of these experiments will be found in Mr. Fuller's report on Special Biological Work. The results show that, even with the enormous nitrification obtained, — one thousand times as great as could be expected in water filtration, — bacteria of various species were able to pass in large numbers. We must conclude that nitrification in itself, though it may be enormous, yet, when incomplete, cannot be depended upon as an effective agent in bacterial removal; although, when nitrification of the organic matter is very complete, it appears to kill the bacteria if by no other means by removing their food supply.

The monthly averages of this filter are as follows: —

Effluent from Filter Tank No. 13.

[Parts per 100,000.]

1892.	Quantity Applied. Gallons per Acre Daily.	Temperature. Sewage.	Temperature. Effluent.	Length of Time Sewage Remained on Surface. Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	50,400	40°	46°	9	None.	.06	.2047	.0101	71.10	25.1000	.0016	.08	75
February,	51,800	38°	45°	13	V. sl.	.11	1.9000	.0240	71.38	20.3800	.6480	.72	294
March,	52,200	36°	44°	9	None	.09	1.6388	.0246	71.24	23.1625	.2420	.32	1,022
April,	52,000	47°	50°	1	"	.08	.0051	.0127	71.32	24.2000	.0003	.10	3,455
May,	46,400	57°	57°	1	"	.10	.0016	.0114	70.50	24.6500	.0001	.13	942
June,	50,000	71°	69°	1	"	.11	.0013	.0149	66.83	23.8000	.0005	.10	2,570
July,	50,400	73°	72°	1	V. sl.	.84	.0027	.0597	4.62	2.2800	.0001	.77	6,890
August,	52,200	72°	71°	1	None.	.16	.0828	.0224	47.52	14.5133	.0000	.14	6,077
September,	52,000	64°	65°	2	"	.14	.0087	.0113	70.50	26.3000	.0003	.17	3,200
October,	50,400	54°	58°	1	"	.39	.0006	.0248	1.40	.7000	.0001	.35	1,445
November,	52,000	45°	51°	2	"	.19	.0007	.0157	.32	.1900	.0005	.14	6,874
December,	52,200	39°	48°	2	"	.14	.0003	.0117	.30	.1425	.0000	.13	1,845

Dose: Effluent from water filter No. 8 or No. 18, with ammonium chloride, the solution containing 28 parts per 100,000 of nitrogen, and an equivalent of sodium carbonate; with the exception of the periods from July 7 to August 8, and September 26 to December 31, when the effluent alone was applied. March 5, 1 gram sodium phosphate was added to the dose. Air changed by aspirator March 26 to April 30.

In the last three months the nitrogen in the effluent as nitrates far exceeded the amount of nitrogen applied, and the bacteria were largely in excess of the number applied, both indicating that there was stored in this filter a large amount of nitrogenous matter, which served as a food supply upon which the bacteria multiplied.

Filter Tank No. 14.

For the first three months of the year Filter No. 14 gave a well-purified effluent, at the rate of 137,000 gallons per acre daily. Afterward the surface became clogged to such an extent that good results could not be obtained, and the upper foot of sand, which had been inverted July 29, 1891 (see Twenty-third Annual Report for 1891, page 542), was reinverted. The old surface sand had not, however, lost its clogging material, and satisfactory results did not follow. On June 20 lime was put upon the filter, to see if that would improve its mechanical condition, but it was without effect. On August 1 the whole upper foot of sand was removed; but for some unknown reason the applied sewage would not pass, and none was applied from August 5 to 25. On August 26 sewage was again applied at a rate of 51,000 gallons per acre daily, and on September 1 the dose was increased to the old amount, 137,000 gallons per acre daily, which disappeared promptly, and the effluent was well purified. The filter continued to do excellent work for the remainder of the year. The monthly average results for the year are as follows: —

Effluent from Filter Tank No. 14.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	134,200	44°	45°	57m.	None.	.14	.0042	.0231	5.56	1.9050	.0004	.28	11,225
February, .	138,000	44°	44°	12m.	V sl.	.19	.0046	.0296	6.80	1.7750	.0003	.33	11,463
March, .	139,400	44°	44°	1h. 4m.	V. sl.	.23	.0172	.0409	5.51	.9880	.0016	.41	25,545
April, .	133,400	46°	50°	28m.	Slight	.52	.5700	.1195	6.56	.3275	.0361	.78	159,000
May, . .	123,800	55°	57°	1h. 19m.	V. sl.	.60	.2620	.0812	6.88	.3140	.0124	.62	71,283
June, . .	107,600	68°	69°	12h. 28m.	Slight	3.28	.6333	.1867	8.57	.0167	.0009	1.41	16,037
July, . .	22,600	69°	72°	–	Slight	3.70	2.2850	.2380	11.59	.0750	.0003	2.69	2,187
August, .	20,000	–	–	–	Slight	1.60	2.6000	.1840	10.10	7.3000	.2200	.92	60,000
September,	138,600	–	64°	8m.	V. sl	.33	.1103	.0603	8.73	2.8725	.0189	.43	33,750
October, .	134,200	–	56°	12m.	V. sl.	.26	.0339	.0494	7.66	2.8800	.0033	.33	132,500
November,	138,600	–	50°	22m.	V. sl.	.26	.0086	.0314	8.54	2.5067	.0009	.26	57,000
December,	134,400	-	47°	22m.	V. sl.	.18	.0081	.0354	6.73	1.9750	.0003	.32	49,000

Surface raked about 3 inches deep each week, except in June, July and August, when surface was raked as follows: 3 inches deep, June 2, 10, 17, 21, 23, 24, July 1, 8, 14, 15, 21, August 3, 4; and 6 inches deep June 29.

Filter Tank No. 17 A.

This filter, of medium fine sand with layers of marble dust, has received during the entire year sewage to which sulphuric acid equal to 49 parts in 100,000 of actual H_2SO_4 was added, the rate of filtration being 51,000 gallons per acre daily. There was an increase of free ammonia during the last two months, but otherwise the effluent has been uniformly well purified, as is shown by the following table of monthly averages: —

Effluent from Filter Tank No. 17 A.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	50,400	44°	43°	60	None.	.06	.0004	.0116	5.26	1.6450	.0000	.14	1
February, .	51,800	44°	42°	39	"	.06	.0054	.0130	6.23	2.2250	.0006	.14	0
March, .	52,200	44°	41°	46	"	.06	.0060	.0147	4.86	2.3933	.0004	.17	1
April, .	52,000	46°	49°	36	"	.09	.0041	.0179	6.54	3.5150	.0004	.21	1
May, . .	46,400	54°	56°	29	"	.08	.0010	.0138	6.89	3.3300	.0000	.20	13
June, .	52,000	68°	69°	19	"	.10	.0014	.0156	8.42	3.0633	.0001	.20	8
July, . .	50,400	70°	71°	17	"	.11	.0018	.0153	11.97	2.2000	.0000	.17	10
August, .	52,200	-	71°	20	"	.12	.0014	.0140	12.00	2.0800	.0004	.17	17
September,	52,000	-	64°	29	"	.12	.0002	.0124	8.70	2.0900	.0000	.17	20
October, .	50,400	-	56°	36	"	.12	.0008	.0129	8.81	2.5750	.0000	.12	8
November,	52,000	-	48°	57	"	.09	.0183	.0125	7.63	2.3367	.0054	.17	101
December,	52,200	-	44°	80	"	.11	.0952	.0170	8.06	2.2300	.0100	.21	65

Sewage applied six times a week. Surface raked about 3 inches deep each week.

Filter Tank No. 19.

The most remarkable feature of this filter has been the persistence of a small quantity of free ammonia in the effluent in presence of a uniformly high nitrification. The dose of sewage in the earlier part of the year was 51,000 gallons per acre daily, applied in six doses each week. Beginning May 9, the sewage was applied in twelve doses instead of six, and after June 20 in three doses each week, but these changes did not produce any marked change in the effluent. On digging into the filter, Jan. 20, 1893, it was found that the sand on one side of the filter was discolored to a great depth, indicating that some of the sewage found its way down in channels by the side of the tank, and this may be the explanation of the ammonia in the effluent. The work of the filter has been, on the whole, very satisfactory, as is shown by the following table of monthly average results: —

Effluent from Filter Tank No. 19.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	50,400	44°	43°	51	None.	.11	.0182	.0168	5.04	1.3800	.0018	.19	2
February, .	51,800	44°	41°	47	"	.12	.0180	.0206	6.26	1.7200	.0028	.26	0
March, .	52,200	44°	41°	73	"	.13	.0154	.0223	4.74	1.4933	.0015	.28	1
April, .	52,000	46°	49°	51	"	.14	.0184	.0224	6.41	2.3100	.0019	.28	1
May, . .	46,400	54°	56°	21	"	.22	.0492	.0173	7.23	2.4133	.0023	.26	3
June, .	52,000	68°	69°	13	V. sl.	.22	.0391	.0228	8.37	2.7300	.0030	.27	68
July, . .	50,400	70°	72°	21	V. sl.	.28	.0223	.0207	10.11	2.7833	.0021	.27	46
August, .	50,400	–	71°	21	V. sl.	.28	.0207	.0224	14.13	2.5500	.0019	.28	335
September,	52,000	–	64°	23	V. sl.	.27	.0170	.0230	7.81	2.0450	.0008	.34	405
October, .	50,400	–	55°	30	None.	.19	.0071	.0202	8.70	2.1100	.0002	.23	243
November,	52,000	–	47°	58	"	.19	.0071	.0187	8.17	1.9833	.0003	.22	136
December,	54,200	–	44°	90	"	.24	.0101	.0175	8.94	2.2050	.0026	.25	138

Sewage applied six times a week till May 7, afterwards twelve times a week till June 22, then three times a week. Surface raked about 3 inches deep each week.

Filter Tanks Nos. 26–31.

These small filters, only 30 inches deep, have been continued with nearly the same doses as in 1891. Nos. 26–28 have received the

sewage containing an excessive quantity of sludge (the analyses of which were given on page 398), while the others have received ordinary sewage.

In March the surfaces of Nos. 27 and 28, to which concentrated sewage was applied, became badly clogged, and early in April the upper foot of sand in each filter was inverted. The surface sands of these filters had been previously inverted in November, 1891, and had again become clogged. The amounts of nitrogen contained in these sands, and in the sand of Filter Tank No. 14, are shown in the following table. For convenience, the original upper six-inch layer is marked A in the table, and the next six-inch layer B.

	Date.	Depth, inches.	Layer.	Amount of Water — By Weight per Cent.	Amount of Water — By Volume per Cent.	Albuminoid Ammonia Parts per 100,000	Organic Nitrogen Parts per 100,000.	Fats per Cent.
Filter No. 14, before inversion,	July 29, '91	0-6	A	16.9	32.5	50.0	82.3	-
		6-12	B	11.4	20.5	12.0	19.8	-
Average,	. .	. .	. .	. .	. .	31.0	51.0	
Filter No. 14, three and one-half months after inversion.	Nov. 18, '91	0-6	B	11.5	19.5	33.5	55.2	-
		6-12	A	15.0	26.5	28.8	47.5	-
Average,	. .	. .	. .	. .	. .	31.1	51.3	
Filter No. 14, eight months after inversion.	Apr. 8, '92	0-6	B	18.8	34.0	71.0	116.8	.07
		6-12	A	19.7	37.0	29.0	47.8	.04
Average,	. .	. .	. .	. .	. .	50.0	82.3	
Filter No. 27, before inversion,	Nov. 16, '91	0-6	A	15.5	29.0	60.7	100.0	-
		6-12	B	6.4	11.0	5.5	9.1	-
Average,	. .	. .	. .	. .	. .	33.1	54.5	
Filter No. 27, six months after inversion.	Apr. 8, '92	0-6	B	13.0	23.0	47.0	77.4	.07
		6-12	A	16.0	29.0	59.0	97.4	.04
Average,	. .	. .	. .	. .	. .	53.0	87.4	
Filter No. 28, before inversion,	Nov. 16, '91	0-6	A	21.3	40.5	61.1	100.6	-
		6-12	B	7.1	11.5	3.8	6.2	-
Average,	. .	. .	. .	. .	. .	32.4	53.4	
Filter No. 28, six months after inversion.	Apr. 11, '92	0-6	B	20.8	39.0	47.0	77.4	.26
		6-12	A	18.2	34.0	48.0	79.1	.09
Average,	. .	. .	. .	. .	. .	47.5	78.2	

Following the inversions there was a very great improvement in the effluent from Filter No. 28 and a marked, but not so great, change in No. 27.

Filters Nos. 30 and 31 have given high nitrification throughout the year. The experiments with sewage containing dyestuffs, made upon filters 28, 30 and 31, have been described above (page 415).

The average work for these filters by months is shown in the following table of results: —

Filter Tanks Nos. 26, 27 and 28.

Note. — Concentrated sewage having the following composition was applied to these filters.

[Parts per 100,000.]

	Ammonia.			Chlorine.	Oxygen consumed	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.				
		Total.	Soluble.			
Average for 1892, ...	2.5094	2.4158	.3754	8.30	10.47	1,708,151

Effluent from Filter Tank No. 26.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, . .	19,200	42°	44°	V. sl.	.16	.0500	.1700	6.19	2.2400	.0645	.76	11,550
February, . .	19,800	44°	44°	V. sl.	.22	.0364	.1340	6.46	1.6250	.0083	.61	92,700
March, . . .	20,100	44°	44°	V. sl.	.22	.0550	.1090	6.25	2.2950	.0087	.60	100,800
April, . . .	19,800	45°	52°	V. sl.	.17	.0270	.1150	6.39	4.0500	.0044	.58	75,000
May, . . .	19,200	–	59°	V. sl	.23	.0480	.2310	7.52	4.8850	.2290	1.17	867,000
June, . . .	19,800	–	72°	V. sl.	.31	.0827	.4647	8.38	3.7867	.1700	2.49	66,000
July, . . .	18,700	–	74°	V. sl.	.33	.0390	.1110	11.36	3.8600	.0048	.76	56,500
August, . .	20,100	–	73°	V. sl.	.27	.0360	.1250	12.76	3.0100	.0540	.79	8,650
September, . .	19,800	–	66°	V. sl.	.26	.0480	.2070	9.29	2.8900	.0575	1.07	47,500
October, . .	18,400	–	57°	V. sl.	.38	.0840	.3910	8.47	1.3450	.4000	1.85	5,200
November, . .	19,800	–	49°	V. sl.	.31	.1533	.3993	8.41	1.8400	.0320	1.73	44,530
December, . .	20,100	–	45°	V. sl.	.36	.1700	.1860	6.72	1.7200	.0082	.96	43,500

Filter Tank No. 27.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	47,500	44°	44°	1m.	None.	.17	.0930	.0390	6.20	1.4650	.0011	.26	3,950
February, .	46,400	44°	43°	9h. 9m.	Slight	.88	.6400	.1553	7.65	.2150	.0006	.85	13,500
March, .	47,500	44°	44°	8h. 4m.	Dec'd	.93	.6825	.1285	5.47	.2775	.0056	.77	106,400
April, .	47,300	45°	51°	2m.	V. sl.	.34	.9010	.1410	6.26	1.2325	.0036	.53	101,400
May, . .	47,500	-	57°	1m.	V. sl.	.60	.3425	.0840	6.66	1.2775	.0022	.43	40,287
June, . .	49,000	-	72°	2m.	None.	.36	.2733	.0647	8.25	1.3667	.0042	.39	12,647
July, . .	49,000	-	74°	2h. 27m.	V. sl.	.48	.2525	.0670	11.03	1.8600	.0072	.42	1,013
August, .	49,200	-	73°	5m.	V. sl.	.28	.0220	.0537	11.16	3.7200	.0018	.32	10,450
September,	49,000	-	66°	15m.	V. sl.	.23	.0240	.0324	8.66	3.0750	.0017	.27	17,700
October, .	45,600	-	57°	3h. 37m.	None.	.22	.0145	.0278	8.30	1.7300	.0005	.26	19,100
November,	26,300	-	49°	20h.	V. sl.	.39	.1548	.0875	8.13	.5000	.0008	.51	21,200
December,	12,500	-	44°	15h. 30m.	Dec'd	1.40	1.9000	.1160	7.45	.4000	.0030	.98	180,000

Sewage applied six times a week. Surface raked about 3 inches deep each week. Surface raked about 6 inches deep February 26, November 12, 18.

Filter Tank No. 28.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	47,500	44°	44°	1h. 7m.	None.	.14	.3800	.0540	5.93	.8600	.0045	.34	7,300
February, .	48,700	44°	43°	2h. 30m.	V. sl.	.70	.6050	.0950	6.67	.3100	.0430	.63	63,300
March, .	47,500	44°	43°	9h.	Great	Red.	1.9150	.1565	5.44	.1175	.0047	1.45	32,412
April, .	41,600	44°	51°	13h. 45m.	Dec'd	Red.	2.7350	.1800	6.36	.9175	.0047	1.58	212,750
May, . .	47,500	-	59°	8m.	V. sl.	.16	.1020	.0633	6.98	1.8200	.0045	.30	127,733
June, . .	49,000	-	71°	6m.	None.	.16	.0068	.0286	8.29	2.6100	.0012	.27	5,150
July, . .	47,500	-	75°	9m.	"	.18	.0044	.0284	10.37	3.6950	.0004	.32	9,100
August, .	49,200	-	73°	19m.	"	.19	.0031	.0275	11.30	3.5850	.0001	.28	275
September,	49,000	-	66°	31m.	"	.21	.0016	.0231	8.65	2.9050	.0000	.31	435
October, .	45,600	-	56°	1h. 25m.	"	.22	.0011	.0237	8.68	2.0250	.0000	.30	156
November,	45,000	-	48°	3h.	"	.24	.0019	.0187	7.33	1.0500	.0000	.32	74
December,	47,500	-	45°	8h. 22m	"	.22	.4400	.0550	8.13	.6000	.0040	.53	7,800

Sewage applied six times a week. Surface raked about 3 inches deep each week.

Filter Tanks Nos. 29, 30 and 31.

Analysis of regular sewage applied to these filters during 1892.

[Parts per 100,000.]

	Ammonia.			Chlorine.	Oxygen consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.				
		Total.	Soluble.			
Average for 1892, ...	2.4517	.7495	.3433	8.33	4.22	809,390

For analysis of this sewage by months see table on page 396.

Filter Tank No. 29.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	25,700	44°	44°	Not determined.	V. sl.	.18	.0840	.0690	5.65	1.8100	.0013	.41	357,150
February, .	28,000	44°	43°		V. sl.	.20	.0550	.0669	5.84	1.8450	.0006	.40	148,100
March, .	28,300	44°	44°		V. sl.	.23	.0450	.0510	6.06	1.9800	.0003	.39	12,600
April, .	28,300	45°	52°		V. sl.	.18	.0234	.0402	6.70	2.8600	.0007	.30	57,250
May, . .	27,200	–	59°		V. sl.	.18	.0423	.0478	7.91	3.1750	.0011	.33	51,600
June, .	28,000	–	72°		V. sl.	.28	.0700	.2647	7.65	2.7967	.0192	1.08	34,600
July, . .	26,600	–	75°		V. sl.	.35	.0418	.1450	10.87	2.8250	.0095	.72	17,250
August, .	28,300	–	74°		V. sl.	.32	.0830	.2550	12.00	2.1550	.0670	1.25	45,000
September,	28,300	–	66°		V. sl.	.31	.0580	.2410	9.00	2.5750	.0220	1.32	109,500
October, .	27,200	–	57°		V. sl.	.34	.1800	.2130	8.03	2.3550	.0185	1.32	6,150
November,	28,000	–	48°		V. sl.	.40	.1853	.2073	8.72	2.1767	.0177	1.25	6,767
December,	28,300	–	44°		V. sl.	.39	.2300	.2060	6.17	2.0750	.0110	1.17	8,050

Sewage applied fifty-four times a week. Surface raked about 1 inch deep each week.

Filter Tank No. 30.

[Parts per 100,000.]

1892.	Quantity Applied — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	47,500	44°	43°	2	V.sl.	.24	.0609	.0477	5.28	1.9500	.0010	.34	23,300
February, .	48,700	44°	43°	1	V.sl.	.19	.0099	.0351	5.87	2.0150	.0007	.30	35,400
March, .	49,200	44°	44°	1	V.sl.	.45	.1250	.0690	5.31	1.7000	.0028	.56	19,100
April, .	49,000	45°	51°	1	V.sl.	.26	.0303	.0436	6.64	2.8950	.0009	.34	76,600
May, . .	47,500	–	59°	1	V.sl.	.31	.0570	.0527	7.22	3.6250	.0024	.35	39,500
June, .	49,000	–	72°	1	Slight	.43	.1900	.0660	8.43	2.9100	.0179	.63	30,167
July, . .	47,500	–	75°	1	Slight	.51	.0900	.0795	11.05	3.2150	.1262	.63	27,500
August, .	49,200	–	73°	1	V.sl.	.59	.1530	.1010	12.03	2.4600	.0600	.68	102,500
September,	49,000	–	66°	1	V.sl.	.31	.0050	.0535	8.85	3.1150	.0026	.37	25,300
October, .	47,500	–	56°	2	V.sl.	.43	.0655	.0482	7.97	3.1600	.0005	.36	47,500
November,	49,000	–	48°	2	V.sl.	.30	.0072	.0254	8.67	2.7933	.0001	.25	19,000
December,	49,200	–	44°	2	V.sl.	.38	.0690	.0549	6.25	2.0650	.0007	.53	49,000

Sewage applied six times a week. Surface raked about 3 inches deep each week.

Filter Tank No. 31.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface. — Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	47,500	44°	43°	8	V.sl.	.13	.0063	.0253	5.70	2.0500	.0001	.25	1,100
February, .	48,700	44°	42°	8	V.sl.	.16	.0116	.0292	6.06	2.1600	.0003	.30	5,352
March, .	49,200	–	43°	4	None.	.17	.0068	.0276	6.10	1.9100	.0002	.29	1,450
April, .	49,000	–	51°	3	"	.15	.0236	.0279	6.76	2.8750	.0002	.25	7,150
May, . .	47,500	–	58°	3	"	.17	.0179	.0237	7.80	4.0200	.0006	.23	2,200
June, .	49,000	–	72°	2	V.sl.	.21	.0380	.0285	8.59	3.5275	.0012	.29	473
July, . .	47,500	–	75°	3	V.sl.	.25	.0133	.0273	10.66	3.4420	.0017	.29	354
August, .	49,200	–	73°	3	None.	Pink.	.0081	.0293	9.42	3.2600	.0009	.37	699
September,	49,000	–	66°	5	"	Pink.	.0058	.0264	8.80	3.1900	.0004	.39	2,175
October, .	47,500	–	56°	6	"	Pink.	.0035	.0274	8.12	3.1450	.0004	.35	927
November,	49,000	–	48°	11	"	Pink.	.0235	.0258	8.15	2.8300	.0008	.28	680
December,	49,200	–	44°	10	"	–	.0371	.0229	6.46	2.3200	.0000	.31	400

Sewage applied six times a week. Surface raked about 3 inches deep each week.

FILTER TANK NO. 32.

The experiment with sewage from which the greater portion of its sludge had been removed by settling was described above (page 405). The work of the filter by months is shown in the following table: —

Filter Tank No. 32.

Analysis of supernatant liquid from settled sewage applied to this filter during 1892.

[Parts per 100,000.]

	Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.				
		Total.	Soluble.			
Average for 1892, ...	2.3796	.4975	.3118	8.16	3.07	658,350

For analysis of this sewage by months see table on page 398.

[Parts per 100,000.]

	Quantity Applied. Gallons per Acre Daily.	Temperature.		Length of Time Sewage Remained on Surface.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
1891.													
December,	127,900	-	47°	3m.	V. sl.	.12	1.2190	.0570	6.80	.0275	.0057	.31	162,080
1892.													
January, .	186,200	-	43°	21m.	V. sl.	.20	1.9850	.0845	6.22	.0250	.0046	.42	109,250
February, .	196,300	-	42°	38m.	V. sl.	.19	1.8740	.0740	6.59	.1180	.0014	.51	11,925
March, .	197,200	-	43°	58m.	None.	.22	1.4720	.0608	5.81	.5020	.0022	.46	492
April, .	196,100	-	50°	17m.	V. sl.	.22	.0981	.0140	6.99	2.5025	.3850	.63	8,283
May, . .	189,900	-	58°	15m.	V. sl.	.33	.0120	.0567	6.87	2.4000	.2853	.72	10,666
June, . .	196,100	-	72°	19m.	None.	.28	.0052	.0352	9.77	1.2420	.0008	.39	1,848
July, . .	155,100	-	75°	4h.	"	.41	.4024	.0627	11.33	1.2425	.0076	.51	21,459
August, .	193,600	-	73°	3m.	"	.22	.0374	.0285	11.31	1.5420	.0019	.29	12,860
September,	196,100	-	66°	8m.	"	.26	.0024	.0231	9.18	1.7340	.0004	.31	819
October, .	180,800	-	56°	18m.	"	.21	.0063	.0229	8.08	1.6125	.0001	.31	172
November,	181,400	-	48°	5h. 50m.	"	.27	.0818	.0237	9.17	1.5050	.0006	.34	311
December,	89,400	-	43°	10h.	"	.20	.0735	.0255	7.92	2.0180	.0013	.27	9,418

Sewage applied six times a week, December 5 to December 12; twelve times a week, December 14 to December 18; twenty-four times a week, December 19 to November 28; afterwards twelve times a week. Surface raked about 3 inches deep each week in December, January and February; 3 inches deep twice each week in March, April, May, June, July and August; 3 inches deep each week in September, October, November and December. Surface raked 6 inches deep February 26 and November 16. August 1, upper 5 inches removed and replaced with 5 inches of No. 9 sand.

EXPERIMENTS AT THE LAWRENCE EXPERIMENT STATION UPON THE PURIFICATION OF WATER BY SAND FILTRATION.

By GEORGE W. FULLER, in Charge of Biological Work at the Station.

Great progress has been made during the past year in our knowledge of the purification of water by means of filtration through sand. In the Annual Report for 1891 it was shown that all or nearly all of the bacteria in the water of the Merrimack River are removed by intermittent filtration through Filter No. 8. This filter has been continued and the degree of purification has remained most satisfactory. The maximum amount of water purified by this filter, however, during the past year has not exceeded 250,000 gallons per acre daily. The adoption by cities and towns of water filtration through such materials would be very costly.

In previous reports attention has been called to the fact that typhoid fever in several cities of the State has been, from time to time, epidemic. The cause of this disease is generally attributed to a germ, namely, the typhoid bacillus. Investigations at the experiment station have confirmed the belief that this germ is sometimes present in sewage-polluted waters, and indicate that it is able to live in such water for at least three weeks; and further investigations by the Board show that high death rates from typhoid fever appear to result from drinking such contaminated water. A large portion of our attention has therefore been devoted to the study of filtering materials coarse enough to purify a municipal water supply economically while removing these disease-producing germs.

Fourteen new water filters have been started during the past year. From a careful study of these, in addition to those described in previous reports, it has been found that filters can be constructed and operated up to rates of 2,000,000 gallons per acre daily, — rates which make their application to public water supplies quite economical, — with the removal of substantially all of the disease-producing germs which may be present in the unfiltered water.

The new filters were so constructed and operated as to throw as much light as possible upon the laws of filtration; that is to say, the experiments were so arranged as to allow direct comparison of the power of bacterial purification of water under different rates of filtration, with sands of different degrees of coarseness, with different depths of the same sand, with the presence of loam layers, and with intermittent and continuous filtration.

Since one of the most important points in the filtration of water is the removal of disease-producing germs, the actual efficiency of these filters has been tested by the application of typhoid fever bacilli, and observations upon their passage through the filters. Repeated applications have also been made of more easily recognized species, such as *B. coli communis* and *B. prodigiosus.* It was found, particularly in the case of the latter species, that with these more results fully as reliable and under more nearly parallel conditions could be obtained than by working with typhoid fever germs. It was further determined by a series of experiments that the life histories of *B. prodigiosus* and *B. typhi abdominalis* in the water of the Merrimack River at Lawrence are quite similar; that is to say, neither species multiplies, but both continue to live, although in greatly diminished numbers, for at least three weeks, — sufficiently long for all requirements of these experiments.

During the earlier portions of the year very large numbers of *B. typhi abdominalis* and other species were respectively applied in single doses to the several filters at different times, and the effluents examined for several days. From long-continued experiments it has been learned that the species of bacteria above named can be so grown that when placed in the river water with their culture medium the numbers of bacteria of these species equal those of other species originally present in the water, while the food material added need not increase the organic matter beyond the limits of variation of the organic matter naturally present in the river water.

Beginning in September, *B. prodigiosus* was systematically applied each day to a large number of the filters, and the application continued throughout the remainder of the year. The general plan of the experiments was to apply this species of bacteria in small repeated doses for ten hours each day, and examine the effluents four times daily at the time when the water containing the applied doses had reached and was coming through the underdrains. It is believed that the results give a thoroughly reliable test of the degree of

bacterial purification effected by the filters, and these are the data which have been largely used in deriving the laws of water filtration.

The numbers of bacteria in the applied river water and in the various effluents have been determined each day. It has been found, however, that the true degree of bacterial purification is somewhat obscured by the presence in the effluents of bacteria which have not come down through the filter directly from the applied water. Some of them appear to have their origin in the outlet pipes and underdrains, where they continue to live upon the very slight amount of food present. This is especially noticeable during the warm summer months, when a few of the most hardy species grow upon the organic matter stored at the surface. Inasmuch as *B. typhi abdominalis* and *B. prodigiosus* do not multiply in the applied water, but continue to live for several weeks in diminished numbers, the advantage of working with such species in determining the hygienic efficiency of filtration is apparent, particularly in the case of *B. prodigiosus*, which has never been found native in this country. (See Report beyond upon Special Biological Work.)

In regard to the degree of bacterial purification effected, it is to be kept in mind that many of the results were obtained under conditions much more severe than would occur in the actual filtration of a public water supply. Thus, in some cases, the number of germs applied was several hundred thousand per cubic centimeter; in some filters the sand was less suitable than would be recommended for any filter of a public water supply, such conditions being here introduced in order to determine the laws of filtration; and the results so obtained are less perfect than might otherwise have been secured. The following table shows the average percentages removed of single species of bacteria under favorable conditions, and by filters which can be constructed on a large scale.

Table showing Efficiency in Water Purification of Suitable Sand Filters.

Number of Filter.	Date — 1892.	Rate—Gallons per acre daily.	Kind of Bacteria.	Per Cent. removed.
36 A, ...	Apr. 11 and May 25,	1,500,000	B. typhi abdom.,	99.93
36 A, ...	Nov. 1-Dec. 10, .	3,000,000	B. prodigiosus,	99.95
33 A, ...	Sept. 16-Oct. 7, .	2,000,000	B. prodigiosus,	99.96
34 A, ...	Sept. 16-Oct. 7, .	2,000,000	B. prodigiosus,	99.98
37, ...	Oct. 7-27, . .	2,000,000	B. prodigiosus,	99.89

The results of the experiments, which show that in all of these filters adapted to the purification of drinking water more than ninety-nine and one half per cent. of the applied bacteria were removed, together with the actual experience of many European cities having remarkably low death rates from diseases known to be capable of conveyance by drinking water, while using filtered water drawn from polluted sources, leave no room for doubt as to the efficiency of such filtration, when properly conducted, as a safeguard against water-carried diseases.

Description of the Experimental Water Filters.

The majority of the filtering materials have been placed in galvanized-iron tanks, about six feet deep and twenty inches in diameter. This gives a surface area of one twenty-thousandth of an acre. The tanks for Filter No. 38 and for Nos. 39 and 40, however, are only three feet and two feet deep, respectively. The bottom of each tank, to which a faucet is attached, is covered by a layer of stones each about one inch by two inches, and upon this are placed successive layers of small stones, which, going upward, decrease in size to a diameter of less than three-eighths of an inch, in a depth of three and a half inches. This is covered with one and one-half inches of coarse mortar sand, above which is placed the filtering material. In the earlier filters the sand was thrown into water which partly filled the tank. It was repeatedly observed, however, that this method of filling produced stratification, and that the presence of layers of the finest particles largely reduced the quantity of water which could be filtered. The filters of more recent construction have been filled dry, and afterward settled by slowly filling with water from below. In this way a compact filling, free from stratification, is obtained. Dry filling, moreover, can be more readily applied to construction on a large scale.

The water to be filtered is applied through a small reservoir attached to the side of the tank, and reaches the filter through an opening, the excess passing off through an overflow. By this means the suspended matter in the water going through the overflow is not deposited on the surface of the sand, and the accumulation of sediment upon the filter comes only from the water which actually passes through it. Some of the filters are operated continuously and others intermittently. In the case of continuous filters a trap is placed on

the faucet to prevent the entrance of air from below, and the rate of filtration is regulated by the width to which the faucet is opened. With intermittent filters no trap is used; the quantity of water to be filtered is regulated at the top, and the faucet is kept wide open. The water is applied for sixteen hours a day, and the filter is allowed to drain during the remaining eight hours. In many of the filters the effluent passes into measuring basins, but in the case of some of the continuous filters the quantity of water passed each day is calculated from observations of the rate of flow. The acting head necessary for the water to pass through the continuous filter at the prescribed rate is shown by the difference in height of the water on the surface of the filter, and that in a vertical glass tube on the outside of the tank, which is connected with the filter near the bottom. From time to time special observations are made on tubes connected with pet-cocks at different levels. The readings on the tube connected at the bottom are taken each day from a scale, in inches, which has its zero mark on the same level as the overflow. When the accumulation of suspended matter on the surface of the sand has become so great that the maximum amount of water which will pass the filter with the faucet wide open falls below the prescribed rate, then the clogged surface sand is removed.

The study of the physical characteristics of materials governing their action as filters has become an important feature of the work at the station. The results of these investigations during the past year are presented beyond by Mr. Hazen. In the following table is given a summary of the physical characteristics of the materials used for filtration of water during 1892. The terms used to express the characteristics of the materials are discussed by Mr. Hazen in the Annual Report for 1891, and in a subsequent portion of the present Report. For convenience the following definitions are given here. The "effective size" of sand grains means that ten per cent. by weight of the sand grains is finer than the diameter given. The "uniformity coefficient" is the ratio A to B when the values of A and B are such that sixty per cent. by weight of the material is finer than A and ten per cent. finer than B. The "maximum rate" is the maximum quantity of water, expressed in millions of gallons per acre daily, which, at a temperature of 50° F., will pass through a filter with no air in its pores and with no suspended matter upon its surface when the acting head is equal to the depth of the

sand. On account of improvements in methods, some of the results differ slightly from those presented in the Annual Report for 1891.

Table showing Materials used for Filtration of Water.

Number of Filter.	Approximate Depth of Material. Inches.	Effective Size of Sand Grains. Millimeters.	Uniformity Coefficient.	Maximum Rate Sand. Million Gallons per Acre daily	Thickness of Loam Layer. Inches.	Effective Size of Loam Grain. Millimeters.	Uniformity Coefficient.	Maximum Rate Loam. Million Gallons per Acre daily.	Method of Operation.	Manner of Filling.
8, . .	60	0.35	7.8	98	8	0.04	-	1.3	Intermittent.	Wet.
18A, . .	63	0.48	2.4	184	0	-	-	-	Intermittent.	Wet.
20*, . .	63	0.48	2.4	184	0	-	-	-	Intermittent.	Wet.
20A*, . .	60	0.48	2.4	184	12†	0.08	2	5	Intermittent.	Wet.
33,* . .	60	0.26	6.0	54	2	0.05	15	2	Intermittent.	Wet.
34,* . .	60	0.26	6.0	54	2	0.05	15	2	Continuous.	Wet.
35,* . .	60	0.26	6.0	54	2	0.05	15	2	Intermittent.	Wet.
36,* . .	60	0.26	6.0	54	2	0.05	15	2	Continuous.	Wet.
33A, . .	60	0.14	2.2	16	0	-	-	-	Continuous.	Dry.
34A, . .	60	0.09	2.1	7	0	-	-	-	Continuous.	Dry.
35A, . .	60	0.20	1.6	32	1	0.07	-	4	Intermittent.	Dry.
36A, . .	60	0.20	1.6	32	1	0.07	-	4	Continuous.	Dry.
37, . .	60	0.20	1.6	32	0	-	-	-	Continuous.	Dry.
38, . .	24	0.20	1.6	32	0	-	-	-	Continuous.	Dry.
39, . .	12	0.20	1.6	32	0	-	-	-	Continuous.	Dry.
40,* . .	12	0.20	1.6	32	1	0.07	-	4	Continuous.	Dry.
41, . .	60	0.14	2.2	16	3‡	0.07	-	4	Intermittent.	Dry.
42, . .	12	0.20	1.6	32	0	-	-	-	Continuous.	Dry.

* Not now in use.
† The material in this case was sand like that in Sewage Filter No. 2.
‡ Removed November 30.

Results Obtained at the Lawrence Experiment Station in 1892.

It has been from a comparative study of the results obtained from the several filters that the most light has been obtained upon the laws of water filtration. For this reason, and in order to prevent repetition as much as possible, a discussion is presented upon the more important subjects, rather than a detailed study of the results of each of the filters. This discussion is followed by a record of the data upon which the conclusions are based. The subject of water filtration ends with a report upon special biological problems which have a direct bearing upon the points in question, and to which references are made in the proper places.

Relative Degrees of Bacterial Purification by Sand Filtration under Different Conditions.

The completeness of bacterial purification by filtration depends upon the character of the sand employed, upon the rate of filtration and other conditions. In the following tables, showing the effect of some of the most important of these conditions, the results obtained with *B. prodigiosus* under comparable circumstances have been uniformly used, as it is believed that these give the most accurate idea of the real efficiency of the filters.

Effect upon Bacterial Purification of Rate of Filtration of Water.

Very early in the investigations upon filtration of sewage it was learned that in the case of some filters the different rates at which sewage passes through exerted much influence upon the bacterial contents of the effluent, the highest bacterial results corresponding with the highest rates. Accordingly, this was one of the first points to be studied in the case of water filtration. The results are given in the following table: —

Fractional Part of One Per Cent. of Applied B. prodigiosus which appeared in the Several Effluents at the Following Rates of Filtration (Gallons per Acre per Day).

Number of Filter.	500,000	1,000,000	1,500,000	2,000,000	3,000,000
18 A,	-	0.15	0.19	-	-
33 A,	0.002	-	-	0.04	-
34 A,	0.001	0.005	-	0.02	-
36 A,	-	-	0 05	-	0.05
37,	-	-	0.01	0.13	-
38,	0.018	-	0.14	0.11	0.31
39,	0.014	0.07	-	0.08	0.52
40,	-	0.07	-	0.09	-
42,	0.016	-	-	0.15	0.55

Many of the results obtained during December do not appear in this table, on account of complications due to cold weather which interfered with the experiments. The results, however, show that more bacteria are able to pass the filters at high rates than at low rates; but all of these filters, at the rates given, removed more than 99.4

per cent. of the number of bacteria applied; and the effect of rates in the above experiments is limited to a variation in the fractional part of one per cent. of the bacteria applied.

Effect upon the Bacterial Purification of Size of Sand Grains.

I. Continuous Filters. (Rate, 2,000,000 Gallons per Acre Daily.)

Number of Filter.	Effective Size of Sand Grains. — Millimeters.	Fractional Part of One Per Cent. of Applied *B. prodigiosus* which appeared in Effluents.
37,	0.20	0.13
33 A,	0.14	0.04
34 A,	0.09	0.02

II. Intermittent Filters. (Rate, 1,500,000 Gallons per Acre Daily.)

18 A,	0.48	0.19
35 A,	0.20	0.06
41,	0.14	0.04

In continuous filtration through the materials and at the rates given the finer sands are slightly more effective than the coarser ones; this is also true of intermittent filters; but the above results are somewhat complicated by the fact that Nos. 35 A and 41 contain loam layers, while No. 18 A received very small single doses delivered from a syphon, and its surface sand was somewhat clogged at the time of this experiment.

Effect upon Bacterial Purification of Depth of Material.

Number of Filter	Approximate Depth of Sand. — Feet.	Fractional Part of One Per Cent. of Applied *B. prodigiosus* which appeared in the Effluent at following Rates in Gallons per Acre Daily.		
		500,000.	2,000,000.	3,000,000.
37,	5	-	0.13	-
38,	2	0.018	0.11	0.31
39 and 42,	1	0.015	0.12	0.53

The depth of material within these limits appears to exert but little influence upon the removal of bacteria, except with the highest rate given. In this case the filter two feet deep removed somewhat more than the filter one foot deep.

Effect upon Bacterial Purification of Loam Layers within a Filter.

With regard to this question, the depth and fineness of both the loam and the sand have to be taken into consideration. The results from Filters Nos. 36 A and 37 indicate that in filters with sand of an effective size of 0.20 millimeter the presence of loam within the filter exerts but little influence upon the bacterial efficiency at rates up to 2,000,000 gallons per acre daily; above this rate the filter containing loam appears to be the more efficient. It has been found also that in filters made of coarser sands the presence of loam layers materially aids in the removal of bacteria. In all of the filters of this construction there was a gradual decrease in the maximum quantity of water which could be made to pass the filters. After five years' service, Filter No. 8, which contains a layer of loam eight inches deep and six inches below the surface, could pass but about 25 per cent. of the original quantity. Early in 1893 the surface sand in this filter was taken off and the loam examined. It was found that the upper quarter-inch of loam was clogged. This portion was removed, and the surface sand replaced. This operation restored the original quantitative efficiency of the filter. The difficulty in removing the clogged loam below the surface of the sand in large filters is obviously a serious objection to this method of construction.

Effect upon Bacterial Purification of Scraping Water Filters.

When water passes through a filter, most of the suspended matter is deposited upon and very near the surface. This accumulating sediment gradually diminishes the space between the sand grains, and increases, therefore, the resistance offered to the passage of water, until the amount of water which will pass is insufficient for practical purposes. It is then necessary to "scrape" the filter; that is, to remove the clogged surface sand. The results of the bacterial examinations of the effluents for the three days before and the three days after scraping are shown below. They extend over the period from September 16 to November 27, when the several filters were running under nearly the same conditions before and after scraping. During this time the number of ordinary water bacteria in the applied water averaged 13,600, and the number of *B. prodigiosus* for the ten hours of daily application 6,400, per cubic centimeter. Many of the results were obtained when filtering water at the rate of 3,000,000 gallons per acre daily.

Table showing the Average Number of Bacteria per Cubic Centimeter in the Effluent of Each Filter as below from Sept. 16 to Nov. 27, 1892.

Number of Filter.	Number of Scrapings.	Water Bacteria.		Number of Scrapings.	B. prodigiosus.	
		Number during the Three Days before Scraping.	Number during the Three Days after Scraping.		Number during the Three Days before Scraping.	Number during the Three Days after Scraping.
33 A,	3	31	45	1	0	3.0
34 A,	5	32	42	4	0.4	0.4
35 A,	4	50	77	3	1.0	3.3
36 A,	4	39	52	4	3.9	6.8
37,	2	21	48	1	0	0.5
38,	6	47	121	4	4.2	11.6
39,	8	52	90	8	3.6	7.3
40,	3	48	29	3	1.3	2.3
41,	5	20	28	2	0.4	1.4
42,	2	109	233	2	13.0	34.0
Totals and averages,	42	44	75	32	2.8	6.7
Average per cent. removed,	-	99.68	99.45	-	99.96	99.89

These results indicate that there is an increase in the number of bacteria in the filtered water after scraping, and during the following three days the effluent usually contains a greater number than at any other time. This is somewhat more noticeable in shallow than in deep filters, and with high rates than low rates of filtration. It should be noted, however, that even at this time of least purification there is still an average removal of more than 99.4 per cent. of the bacteria found in the applied water. With coarser sands than have been employed in these experiments the effect of scraping upon the bacterial contents of the effluent would probably become more marked.

Distribution of Bacteria within a Continuous Sand Filter.

On October 26 the sand, then nine inches deep, was taken out of Filter No. 40, which had been run continuously since May 2, and examined bacteriologically. The filter was scraped last on October 15, and was operated at the rate of 2,000,000 gallons per acre daily. The result of the examination was as follows: —

Number of Bacteria found in the Different Parts of a Sand Filter.

	Water Bacteria.	B. prodigiosus.	Per Cent. which B. prodigiosus is of Water Bacteria.
Number of bacteria applied since last scraping,	18,000,000,000	2,340,000,000	13
Number found in upper quarter-inch of sand, .	2,727,000,000	272,700,000	10
Number found in first inch, ...	4,000,000,000	290,000,000	7
Number found in second inch, ...	612,000,000	None found.	-
Number found in third and fourth inches, .	220,000,000	None found.	-
Number found in remaining five inches, . .	100,000,000	None found.	-
Total for filter, ...	4,932,000,000	290,000,000	6

From this table it appears that the water bacteria found in the filter formed 27 per cent. of those applied since the last scraping; and that 13 per cent. of the *B. prodigiosus* applied during this time remained in the filter. Of the water bacteria, 82 per cent. were found in the upper inch and 55 per cent. in the upper quarter-inch. In the case of *B. prodigiosus*, 93 per cent. were found in the upper quarter-inch; and, furthermore, this species, which is apparently very similar to *B. typhi abdominalis* in its mode of life in water, and which the results show to have nearly the same duration of life at the surface of the sand as the average water species, did not pass more than an inch into the filter in numbers which could be recognized. The fact that very small numbers of this species of bacteria were found in the effluent, however, shows that it did pass below the upper inch, but to a very limited extent. For further consideration of the species determinations, see "Special Biological Work" beyond.

Effect upon Bacterial Purification of Method of Application of Water.

An intermittent filter yielding the same quantity of water daily as a similarly constructed continuous filter is obliged to do its work in a shorter time, and, accordingly, has to work at a faster rate.

Summary of Bacterial Results from Filters No. 35A and 36A.

I. Filter No. 35A (Intermittent).

Date — 1892.	Approximate Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number Applied which Appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,000,000	5,390	0	12	0	0.22	-
July,	1,000,000	4,300	0	24	0	0.56	-
August,	1,000,000	5,030	0	37	0	0.74	-
September 1-15,	1,500,000	8,050	0	95	0	1.08	-
September 16-October 7,	1,500,000	18,500	4,160	105	2.95	0.57	0.07
October 8-31,	1,500,000	10,370	0	52	0	0.50	-
November 1-16,	1,000,000	16,900	13,400	38	3.80	0.22	0.03
November 17-December 31,	1,000,000	5,970	0	31	0	0.52	-

II. Filter No. 36A (Continuous).

Date — 1892.	Gallons per Acre Daily.	Water Bacteria (Applied).	Bacillus prodigiosus (Applied).	Water Bacteria (Effluent).	Bacillus prodigiosus (Effluent).	Water Bacteria (Per Cent.).	Bacillus prodigiosus (Per Cent.).
June,	1,500,000	5,390	0	12	0	0.22	-
July,	1,500,000	4,300	0	53	0	1.23	-
August,	1,500,000	5,030	0	87	0	1.73	-
September 1-15,	1,500,000	8,050	0	22	0	0.27	-
September 16-October 7,	1,500,000	18,500	4,160	74	1.86	0.40	0.04
October 8-31,	1,500,000	10,370	0	33	0	0.32	-
November 1-December 11,	3,000,000	9,260	9,790	42	4.80	0.45	0.05
December 12-31,	2,000,000*	7,190	4,710	87	3.50	1.21	0.03

* During this time the filter ran at a rate of 3,000,000 gallons during the day and 1,000,000 during the night. The number of bacteria in the effluent was abnormally high, as is explained further on.

These two filters were constructed, and, with the exception of the method of application of the water, were operated as nearly alike as possible. In June the removal of bacteria was the same. During the warm weather of July and August there appeared to be a peculiar growth of bacteria in the filters, as is stated beyond. The growth was much less marked in case of the intermittent filter, due probably to a removal of more of the available food material by nitrification, and perhaps also to the daily draining and partial drying at the surface. There were fewer bacteria in the effluent of the intermittent filter during these months. In the first half of September the effect of bacterial growth apparently ceased in the continuous filter, while the number of bacteria in the effluent of the

intermittent filter increased during this time. Taking into consideration the rate of filtration, the continuous filter continued to be slightly more effective up to the time when the cold weather interfered with the accuracy of the experiments.

The results upon Filters No. 33A and 41 point in the same direction, but have been disregarded, because No. 41, until November 30, contained a three-inch layer of loam, and after its removal the sand was so loosened that the filter did not recover its normal efficiency during the remainder of the year.

Before making definite conclusions upon the relative efficiency and real value of the two methods, it will be necessary to obtain more data, especially upon filters which have been longer in service.

The Scraping of Water Filters.

Reference has already been made to the accumulation of suspended matter upon the surface of the filters, which increases the frictional resistance offered to the passage of the water, and necessitates from time to time a removal of the clogged sand. As scraping is one of the principal items of expense in the operation of a filter plant, it is of importance to note the effect of this upon the quantitative efficiency of filters of different construction.

The depths of sand in the filters and of water above the sand are given in the following table. Daily observations of the pressures necessary to produce the given rate in the several continuous filters appear, together with the other data, in the tables beyond. Filter No. 36 A has no pressure tube, but the pressures are similar to those for No. 37.

Table showing Depths of Sand and of Water above Sand, in Inches.

Number of Filter.	April, 1892.		Sept. 1, 1892.		Nov. 18, 1892.	
	Sand.	Water.	Sand.	Water.	Sand.	Water.
33 A, ...	60	4.5	54.5	10	54	10.5
34 A, ...	60	4.5	54	10.5	52.8	11.7
35 A, ...	57.5	6.5	55.5	8.5	54	10
36 A, ...	58	6	55	9	54.3	9.7
37, ...	61	10	59	12	58	13
38, ...	24	5.5	20.5	9	19.3	10.2
39, ...	12	5.5	9	8.5	7	10.5
40, ...	12	5.5	9.5	8	8.5*	9
41, ...	60	4.5	58.5	6	57.5	7

* Discontinued October 26.

It was found that there was a settling of the filters for a short time after they were put in operation, and that the decrease in depth from April to September cannot be attributed wholly to the results of scraping. Accordingly, the results from September 1 to November 18 have been used for comparative study. In the tables beyond the results on those days on which the filters were scraped are underlined.

Sand removed by Scraping and Quantitative Efficiency, Sept. 1 to Nov. 18, 1892.

NUMBER OF FILTER.	Number of Scrapings.	Depth of Sand. — Inches.	Depth of Water above Sand. — Inches.	Average Depth of Sand Removed at each Scraping. — Inches.	Average Quantity of Water passed between Scrapings. — Million Gallons per Acre.
33A,	3	54.25	10.25	0.17	45
34A,	6	53.40	11.10	0.20	24
35A,	4	54.75	9.25	0.37	38
36A,	3	54.65	9.35	0.23	60
37,	3	58.50	12.50	0.33	56
38,	5	19.90	9.60	0.24	32
39,	8	8.00	9.50	0.25	16
40,	5	9.00	8.50	0.20	19
41,	5	58.00	6.50	0.20	31

The amount of water which will pass a filter between scrapings depends upon the amount of suspended matter in the applied water, and the temperature, as well as upon the nature of material and the construction of the filter. Much less water will pass a filter at 32° F. than at 75° F., owing to the increased viscosity of the water. In some calculations a temperature correction has been applied, using 50° F. as the average temperature for the year. The question of temperature does not affect the results in this table, beyond the limits of error in measurement. The results of forty-two scrapings during this period indicate that the average depth of clogged sand necessary to be scraped from the surface of these filters is about 0.25 inch. It is to be stated that in scraping the filters much care was taken to remove just enough sand to do away with the clogging and reduce the acting head, when the filter was in operation, to a minimum. The results of very careful observations when the filters were quite new indicated that it was necessary to remove about 0.10 inch. Similar observations in May, 1893, after the filters had been in operation one year, showed the amount to have increased, the

amounts varying from 0.10 to 0.22 inch. The quantity to be removed differed somewhat in the several filters. It was found to decrease as the fineness of the sand increased and the depth of the filter decreased. This is because less water under these conditions passed the filters between scrapings. This explanation is made clear in the following tables and conclusions.

Bringing together for comparison the information thus far obtained as to the quantities of water passed by the several filters under different conditions of construction and operation, we find —

The Effect of Rate of Filtration upon Quantity of Water filtered between Scrapings.

Number of Filter.	Rate — Gallons per Acre Daily.	Average Quantity of Water filtered between Scrapings. — Gallons per Acre.
39 and 40, continuous, ...	2,000,000	16,000,000
40 and 39, continuous, ...	1,000,000	16,000,000

Filter No. 39 was run for a month at the rate of 2,000,000 gallons per acre daily, and Filter No. 40 at the rate of 1,000,000 gallons, after which the rates were reversed and the filters run without change for another month. These results indicate that within these limits and under equal conditions the quantity of water passed by a filter between successive scrapings is not influenced by the rate of filtration.

The Effect of Size of Sand Grain upon Frequency of Scraping.

Number of Filter.	Method of Operation.	Effective Size of Sand Grain. — Millimeters.	Average Quantity of Water filtered between Scrapings. — Gallons per Acre.
35A, ...	Intermittent,	0.20	38,000,000
41, ...	Intermittent,	0.14	31,000,000
36A, ...	Continuous,	0.20	60,000,000
37, ...	Continuous,	0.20	56,000,000
33A, ...	Continuous,	0.14	45,000,000
34A, ...	Continuous,	0.09	24,000,000

In both continuous and intermittent filtration the filters with the finer sands require more frequent scraping than those with coarser sands. For details see the tables beyond.

Effect of Depth of Filter upon Frequency of Scraping.

NUMBER OF FILTER. (Effective Size of Sand Grain = 0.20 mm.)	Depth of Sand. — Inches.	Total Depth of Filter. — Inches.	Average Quantity of Water filtered between Scrapings. — Gallons per Acre.
36A,	54.65	69.	60,000,000
37,	58.50	76.	56,000,000
38,	19.90	34.5	32,000,000
39,	8.00	22.5	16,000,000
40,	9.00	22.5	19,000,000

The shallow filters required more frequent scraping than the deeper ones. This appears to be entirely due to the greater head available in the deeper filters for overcoming friction.

Effect of Loam Layers within a Filter upon Scraping.

Since the object of scraping a filter is to do away with the clogging at the surface, and it is known that the rate of filtration does not influence the frequency of scraping, it is evident that in the case of many filters the presence of loam layers within a filter would have little or no influence upon the frequency of scraping. It is to be said, however, that in filters of coarse sand, where the presence of loam would materially aid in purification, there would be a slow and gradual clogging of the loam layer, and this layer would itself eventually have to be scraped. The difficulties attending this operation have been presented on page 457.

Effect of Method of Application of Water upon Frequency of Scraping.

NUMBER OF FILTER.	Method of Operation.	Average Quantity of Water filtered between Scrapings. — Gallons per Acre.
35 A,	Intermittent,	38,000,000
36 A,	Continuous,	60,000,000
41,	Intermittent,	31,000,000
33 A,	Continuous,	45,000,000

The continuous filters required scraping less frequently than the intermittent ones. This is explained in part by the less head required with slow motion through continuous filters, as pointed out above, and in part by the increased frictional resistance to the passage of water through intermittent filters, due to the presence of air in the pores of the sand.

Chemical Purification of Water by Filtration.

One important object of the removal of organic matter from ordinary drinking water is to lessen the food supply available for the bacteria which are present. A comparison of the efficiency, with regard to removal of organic matter, of filtration under different conditions is presented below. The results given in these tables were obtained under conditions as similar as possible.

Table showing Per Cent. of Albuminoid Ammonia in Applied Water which appeared in the Effluent at Different Rates of Filtration.

Number of Filter.	Rate in Gallons per Acre Daily.				
	500,000 Gallons per Acre Daily.	1,000,000 Gallons per Acre Daily.	1,500,000 Gallons per Acre Daily.	2,000,000 Gallons per Acre Daily.	3,000,000 Gallons per Acre Daily.
33A,	37	–	–	40	–
34A,	37	34	–	43	–
35A,	–	38	49	–	–
36A,	–	–	44	–	46
37,	–	–	39	40	–
38,	–	–	50	48	–
39,	–	47	–	57	–
40,	–	51	–	44	–
41,	–	–	46	–	–
42,	–	–	–	49	–

In filters of these materials, and in which nitrification is well established, the rate of filtration within these limits appears to exert but little influence upon the removal of organic matter. In the case of Filter No. 36A, the amount removed at a rate of 3,000,000 was only a very little less than at 2,000,000 gallons per acre daily.

Effect of Size of Sand Grain.

I. Continuous Filters. (Rate, 2,000,000 Gallons per Acre Daily.)

Number of Filter.	Effective Size of Sand Grain. — Millimeters.	Per Cent. of Albuminoid Ammonia in Applied Water which appeared in Effluents.
37,	0.20	40
33A,	0.14	40
34A,	0.09	43
II. Intermittent Filters. (Rate, 1,500,000 Gallons per Acre Daily.)		
35A,	0.20	49
41,	0.14	46

In continuous and intermittent filtration through materials of these sizes and at the given rates there is no very great difference in the amounts of organic matter removed from the applied water.

Effect of Depth of Material.

Number of Filter.	Depth of Material. Feet.	Per Cent. of Albuminoid Ammonia in Applied Water which appeared in Effluents at the Following Rates of Filtration in Gallons per Acre Daily.		
		500,000.	2,000,000.	3,000,000.
37,	5	39	40	-
38,	2	50	48	63
39 and 42,	1	-	47	69

The deeper filters, of this material, are somewhat more effective in the removal of organic matter than the shallower ones.

Effect of Method of Application of the Water.

The experiments made on this point are not yet sufficient to allow extensive generalizations. In the following table are the final averages of some results obtained from four pairs of filters. The two filters of each pair were operated similarly except in regard to the method of application. The construction of the members of each pair was also as nearly the same as possible except in case of No. 41, which, until November 30, contained a layer of loam, while its mate, No. 33A, had none. It took some time for nitrification to become well established, and the results obtained before this period have been disregarded.

Continuous Filters.			Intermittent Filters.		
Number of Filter.	Per Cent. of Albuminoid Ammonia in Applied Water which appeared in the Effluent.	Nitrogen as Nitrates (parts per 100,000).	Number of Filter.	Per Cent. of Albuminoid Ammonia in Applied Water which appeared in the Effluent.	Nitrogen as Nitrates (parts per 100,000).
34 (Feb.-April),	23	.0250	33 (Feb.-April),	20	.0250
36 (Feb.-March),	24	.0297	35 (Feb.-March),	24	.0293
33 A (June-Dec.),	41	.0285	41 (July-Dec.),	42	.0387
36 A (June-Dec.),	44	.0236	35 A (June-Dec),	43	.0443

These results show that there was practically the same amount of albuminoid ammonia in the effluents of the continuous and the inter-

mittent filters. The close correspondence in the actual amounts of albuminoid ammonia may be seen from the tables of monthly averages for the several filters given beyond. The amount of nitrates in the effluents was greater in the case of the intermittent filters when continued through the summer months. The first two sets of filters were started in the winter and stopped in the early spring, before the season of most active nitrification.

Dissolved Oxygen in the Effluents.

The following table shows the average amount of dissolved oxygen in the effluents of the various filters: —

Per Cent. which the Oxygen dissolved in the Applied Water and Effluents was of that necessary for Saturation at actual Temperatures.

Date — 1892.	Applied Water.	Effluents from Filter Number.										
		18 A	33 A	34 A	35 A	36 A	37	38	39	40	41	42
June, ...	83	100	48	60	100	37	50	56	62	55	100	-
July, ...	85	100	55	44	93	45	30	56	68	60	89	-
August, . . .	71	93	40	70	98	26	71	50	50	46	93	-
September, . . .	87	96	36	38	100	41	32	50	41	56	93	-
October, . . .	80	94	45	50	97	42	46	47	50	48	92	-
November, . . .	100	90	49	53	95	84	70	83	86	-	93	90
December, . . .	100	98	70	70	100	85	83	65	80	-	100	80

The Removal of Color from Water by Filtration.

From the results obtained from these filters it is found that new sand is more efficient in the removal of color from the water of the Merrimack River than sand which has served some time as a filtering material. The loss, in part, of this power appears to depend upon the quantity of water which has passed a filter. Thus, in the case of Filter No. 8, which contains a loam layer eight inches thick and six inches below the surface, and which has filtered water since November, 1887, at rates of filtration of from 100,000 to 250,000 gallons per acre daily, the effluent was for two years colorless. During the third year it was slightly colored at times but colorless for the greater part of the time. During the fourth and fifth years of service the effluent of this filter was very slightly but uniformly colored.

It has also been found that the deeper filters were more efficient in removing color than the shallower ones. This is doubtless owing solely to the smaller quantity of sand in proportion to the amount of water filtered. The results thus far obtained upon filters constructed in 1892 indicate that the presence of thin layers of loam, the differences in size of sand grains and the rates of filtration within the given limits exert no great influence upon the removal of color. The results indicate, however, that when the applied water was very highly colored, just after a heavy rain, the effluents of intermittent filters were at times less colored than those of continuous filters.

The following table shows the efficiency of the filters after different lengths of service: —

Percentage of Color of Applied Water which appeared in the Effluent of the Filters after filtering Different Amounts of Water (Gallons per Acre).

Amount Filtered.	100,000,000	200,000,000	300,000,000	400,000,000
Filters five feet deep, ...	40	45	50	55
Filters one to two feet deep, . .	60	65	68	70

The Water taken from the Merrimack River and applied to the Experimental Filters.

Water taken from the Merrimack River is applied to all of the water filters and is brought through a small pipe, about four hundred feet long, from the North Canal of the Essex Company. It is substantially the same as the river water above Lawrence, which is pumped into the city reservoir.

The turbidity, sediment and odor are usually very slight, but after heavy rains and during the spring freshets the turbidity and sediment become very marked. The results of analyses are given in the following table. It will be seen that during the early part of the year there were fewer bacteria in the water than in the latter part, and that the numbers gradually decreased during the first five months. This was due to their disappearance in the pipe in which there was an accumulation of sediment and iron-rust (see page 526). On May 21 the one-inch iron pipe was replaced by a two-inch galvanized iron pipe, and a large excess of water was kept constantly running through to insure its normal character. From this time forth the number of bacteria in the water applied to the filters was the same as in the water in the river.

Monthly Averages of Weekly Analyses of Water applied to Filters.
[Parts per 100,000.]

Date — 1892.	Temperature. Degrees F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,*	36°	.36	.0033	.0156	.15	.0140	.0001	.53	2,088
February,*	37°	.27	.0057	.0130	.21	.0165	.0002	.36	1,550
March,*	38°	.28	.0039	.0144	.19	.0174	.0002	.38	1,295
April,*	51°	.26	.0028	.0145	.14	.0117	.0001	.36	548
May,*	57°	.47	.0037	.0135	.11	.0110	.0003	.48	405
June,	72°	.49	.0049	.0155	.13	.0102	.0001	.51	5,390
July,	76°	.51	.0081	.0186	.14	.0097	.0001	.48	4,300
August,	74°	.55	.0069	.0200	.21	.0116	.0001	.50	5,030
September,	66°	.51	.0066	.0178	.17	.0112	.0001	.53	13,250
October,	56°	.36	.0080	.0181	.25	.0115	.0001	.30	12,880
November,	43°	.50	.0056	.0189	.20	.0152	.0001	.51	11,160
December,	36°	.47	.0056	.0167	.21	.0162	.0001	.45	5,550

* Merrimack River water from one-inch iron pipe.

Detailed Account of the Work of the Several Sand Filters in 1892.

The following pages contain a brief description, together with a complete summary, of the results from the experimental filters in use during the past year. With regard to bacterial results there will be found on pages 490–525 the daily determinations beginning in June and continuing throughout the year. Bacterial examinations of the effluents were also made nearly every day from January 1 to June 1, and during this time many experiments were made upon the passage of typhoid fever germs and other prominent species of bacteria through the filters. The results of these special experiments, and the averages of the daily determinations after June 1, arranged in periods, and showing the percentages of applied bacteria which appeared in the effluents, are presented in tables along with others in which are given the monthly averages of the chemical analyses. The daily results up to June 1 have not been arranged in this way because, on account of the small numbers of bacteria in the applied water, as explained above, the results expressed in per cents. do not give a fair idea of the efficiency of the filters. When the averages of the daily results, however, differed from averages of results on dates corresponding to chemical examinations, the former have been substituted in the tables showing the monthly averages of the chemical analyses.

Filter No. 8.

The earlier history of this filter is given in the special report upon Purification of Sewage and Water, page 602, and in the Annual Report for 1891, pages 608 and 624. Filter No. 8 is filled with sand like that of Filter No. 6, of an effective size of 0.35 millimeter, and contains a layer of loam eight inches thick, the top of which is six inches below the surface. The depth of the filter is five feet.

The highest rate of filtration obtained was 274,000 gallons per acre daily. The maximum quantity of water which could pass the filter when water was applied sixteen hours a day has decreased perceptibly during this, the fifth year of service, due to a clogging at the surface of the loam. Early in 1893 a quarter-inch of clogged loam was removed and the original quantitative efficiency was at once restored.

The following table contains the average monthly results of the chemical and bacterial examinations. The bacterial results in January were unusually high, due to a disturbance caused by readjusting the outlet pipe. There is reason to believe that none of the bacteria in the applied water pass through this filter, as was shown in the Annual Report for 1891. The effluent is practically colorless, has no taste or odor or objectionable organic matter and compares very favorably in every way with the best spring waters.

Monthly Averages of Analyses of Effluent of Filter No. 8.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	82,800	36°	39°	.02	.0002	.0033	.16	.0297	.0000	.07	37
February,	121,600	37°	36°	.04	.0006	.0043	.22	.0332	.0000	.09	2
March,	146,400	38°	37°	.04	.0004	.0046	.20	.0334	.0000	.08	3
April,	130,600	51°	48°	.04	.0004	.0048	.16	.0405	.0000	.10	11
May,	123,400	57°	55°	.07	.0000	.0028	.13	.0442	.0000	.09	11
June,	159,800	72°	71°	.06	.0002	.0035	.14	.0468	.0000	.09	5
July,	176,000	76°	75°	.07	.0023	.0071	.15	.0405	.0000	.11	7
August,	217,000	74°	75°	.07	.0003	.0040	.25	.0364	.0000	.08	20
September,	187,000	66°	67°	.07	.0004	.0041	.19	.0392	.0000	.10	4
October,	134,400	56°	55°	.06	.0005	.0036	.25	.0330	.0000	.05	10
November,	118,200	43°	47°	.06	.0003	.0040	.22	.0254	.0000	.07	2
December,	94,200	36°	40°	.07	.0003	.0033	.23	.0295	.0000	.09	4

Filter No. 18A.

This filter contains five feet and three inches of sand like that of Filter No. 1, of an effective size of 0.48 millimeter. By means of a small reservoir with a siphon attachment water has been regularly applied intermittently at frequent intervals, nights, days and Sundays, in doses equivalent to 5,000 gallons per acre. There was no trap attached to the faucet which was kept wide open. A summary of the earlier results is given in the Annual Report for 1891, page 609.

The first experiment upon the passage of typhoid fever germs will be described in full. In the remaining experiments of this nature the method of procedure was very similar and the details, therefore, have been omitted.

On March 2, at 9.15 A.M., typhoid fever germs of Eberth with the dilute bouillon in which they were grown and some common salt were placed in the small reservoir, well mixed with the water and applied to the filter. The salt, which does not appear to interfere with the continuance of life of these bacteria, was used to trace the course of the dose through the filter. The water as it was delivered upon the filter contained 145,000 typhoid germs per cubic centimeter and 320 parts of chlorine per 100,000. The results obtained at frequent intervals for several days are presented in the following table: —

Table showing Results of Application of Typhoid Fever Germs of Eberth to Filter No. 18 A, March 2 to 4, 1892.

Date — Hour.	Gallons Passed.	Chlorine (Parts per 100,000).	Per Cent. of Dose in Effluent.	Bacteria per C.C. in Effluent.	Date — Hour.	Gallons Passed.	Chlorine (Parts per 100,000).	Per Cent. of Dose in Effluent.	Bacteria per C.C. in Effluent.
March 2.					*March 2* — Con.				
9.15 A.M.,	0	0.20	0	6	11.45 A.M.,	5.87	0.20	0	4
9.30 A.M.,	0.59	0.20	0	3	12.00 M.,	6.40	0.21	0.003	3
9.45 A.M.,	1.18	0.20	0	8	12.15 P.M.,	6.92	0.24	.012	1
10.00 A.M.,	1.78	0.20	0	14	12.30 P.M.,	7.46	0.47	.084	6
10.15 A.M.,	2.38	0.20	0	0	12.45 P.M.,	7.99	0.82	.194	7
10.30 A.M.,	2.99	0.20	0	10	1.00 P.M.,	8.53	1.55	.422	5
10.45 A.M.,	3.60	0.20	0	13	1.15 P.M.,	9.06	2.75	.797	10
11.00 A.M.,	4.21	0.20	0	9	1.30 P.M.,	9.59	3.75	1.109	4
11.15 A.M.,	4.81	0.20	0	9	1.45 P.M.,	10.12	5.25	1.158	8
11.30 A.M.,	5.34	0.20	0	15	2.00 P.M.,	10.65	6.65	2.02	2

Table showing Results of Application of Typhoid Fever Germs of Eberth to Filter No. 18 A, March 2 to 4, 1892 — Concluded.

Date — Hour.	Gallons Passed.	Chlorine (Parts per 100,000.)	PerCent. of Dose in Effluent.	Bacteria per C.C. in Effluent.	Date — Hour.	Gallons Passed.	Chlorine (Parts per 100,000.)	PerCent. of Dose in Effluent.	Bacteria per C.C. in Effluent.
March 2 — Con.					*March 2* — Con.				
2.15 P.M., .	11.18	7.45	2.26	5	9.00 P.M.,	25.37	0.79	0.178	6
2.30 P.M., .	11.72	8.30	2.53	8	9.30 P.M.,	26.40	0.69	0.153	3
2.45 P.M., .	12.25	8.80	2.69	8	10.00 P.M.,	27.50	0.55	0.109	1
3.00 P.M., .	12.79	9.20	2.81	6	*March 3.*				
3.15 P.M., .	13.32	9.42	2.88	105	5.25 A.M.,	41.00	0.20	0	1
3.30 P.M., .	13.85	9.38	2.86	8	8.00 A.M.,	45.00	0.20	0	2
3.45 P.M., .	14.37	8.88	2.71	*6,140	9.00 A.M.,	47.00	0.20	0	1
4.00 P.M., .	14.89	8.40	2.56	3	10.00 A.M.,	49.00	0.20	0	5
4.30 P.M., .	15.93	7.10	2.16	*11,100	11.00 A.M.,	51.00	0.20	0	5
5.00 P.M., .	17.00	5.50	1.66	73	12.00M., .	53.00	0.20	0	18
5.30 P.M., .	18.05	4.12	1.22	9	2.00 P.M.,	57.00	0.20	0	5
6.00 P.M., .	19.10	3.30	0.97	9	3.00 P.M.,	59.00	0.20	0	0
6.30 P.M., .	20.13	2.32	0.66	15	5.00 P.M.,	64.00	0.20	0	4
7.00 P.M., .	21.17	1.80	0.50	4	*March 4.*				
7.30 P.M., .	22.20	1.22	0.32	2	10.00 A.M.,	100.00	0.20	0	1
8.00 P.M., .	23.26	1.10	0.281	1	2.00 P.M.,	108.00	0.20	0	1
8.30 P.M., .	24.31	0.92	0.225	3	5.00 P.M.,	115.00	0.20	0	1

* Plates contaminated.

The average rate of filtration was 980,000 gallons per acre daily. All of the bacterial plates were carefully examined for typhoid fever germs and on the plate from the sample taken March 2, at 3.15 P.M., 35 of these colonies were found. In no other case could this species of bacteria be detected.

It will be seen that it was at this hour that the largest percentage of the applied dose was passing through the outlet pipe. It is estimated from the determinations made, reckoning from the number found in the one sample and the quantity of water passing between samples, that 70,000 typhoid germs, or 0.05 per cent. of the number applied, passed the filter.

This experiment was a very severe test upon the efficiency of this filter in removing bacteria because the number applied was probably many times greater than would ever occur in any case in actual practice. While this experiment is instructive, experiments made during the latter part of the year are fairer because the bacteria were applied

in small and long-continued doses at frequent intervals, and it is these later results which have been used in the foregoing discussion.

The sand at the surface of this filter gradually became quite clogged. On September 26 the surface was so clogged that the water failed to disappear in the interval between applications. In order to keep the action of the filter intermittent the sand was raked to a depth of one inch. On November 15 the water was again found to stand on the surface continually. One-half inch of clogged sand was removed. This did not remedy it and it was necessary on the following day to remove two inches more before clean sand was reached and the applied water was able to disappear promptly.

Table showing the Results of Application of Bacteria, in Single Doses, to Filter No. 18 A.

DATE — 1892.	Rate of Filtration. Gallons per Acre Daily.	Species of Bacteria applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
March 2,	980,000	B. typhi abdom.,	0.05
11,	1,000,000	B. typhi abdom.,	1.00
18,	780,000	B. prodigiosus,	0.60
23,	860,000	B. typhi abdom.,	0.10

The following table contains the averages of the daily bacterial results upon this filter: —

Bacterial Results, Filter No. 18 A.

DATE — 1892.	Rate of Filtration. Gallons per Acre Daily.	BACTERIA PER CUBIC CENTIMETER IN APPLIED WATER.		BACTERIA PER CUBIC CENTIMETER IN EFFLUENT.		PER CENT. OF NUMBER APPLIED WHICH APPEARED IN EFFLUENT.	
		Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
August,	1,000,000	5,030	0	49	0	0.97	-
September 1-15,	1,000,000	8,050	0	73	0	0.91	-
September 16-30,	1,000,000	17,070	4,530	117	6.50	0.68	0.14
October,	1,500,000	12,880	2,780	96	4.58	0.74	0.17
November,	1,500,000	11,160	0	72	0	0.65	-
December,	1,500,000	5,550	0	39	0	0.70	-

Monthly Averages of Analyses of Effluent of Filter No. 18A.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	860,000	36°	41°	.23	.0004	.0081	.15	.0225	.0000	.32	61
February,	1,020,000	37°	39°	.16	.0008	.0064	.20	.0212	.0000	.21	6
March,	960,000	38°	39°	.17	.0007	.0072	.21	.0258	.0000	.21	9
April,	960,000	51°	49°	.18	.0005	.0068	.14	.0267	.0000	.22	5
May,	1,000,000	57°	56°	.30	.0003	.0067	.11	.0187	.0000	.34	3
June,	1,080,000	72°	72°	.29	.0004	.0080	.13	.0250	.0000	.33	7
July,	880,000	76°	75°	.26	.0005	.0068	.15	.0235	.0000	.31	6
August,	1,060,000	74°	74°	.30	.0007	.0096	.19	.0273	.0006	.37	49
September,	1,020,000	66°	66°	.24	.0004	.0081	.22	.0275	.0000	.29	95
October,	1,500,000	56°	56°	.21	.0006	.0084	.27	.0225	.0000	.21	96
November,	1,520,000	43°	43°	.45	.0007	.0105	.19	.0175	.0000	.46	72
December,	1,200,000	36°	35°	.37	.0012	.0104	.19	.0235	.0000	.38	39

Filters Nos. 33, 34, 35 and 36.

These four filters were filled in December, 1891, with sand, like that of Filter No. 6, from which the stones and coarsest sand had been removed by sifting. The effective size of the sand used was 0.26 millimeter. Each filter contained one inch of yellow loam one foot below the surface. The materials were thrown into water which partly filled the tanks. Two of the filters were run continuously and two intermittently. One pair of filters was placed in a separate building where they could be studied to better advantage in regard to the passage of typhoid fever or other pathogenic germs. The method of application and examination in these experiments was very similar to that in the case of Filter No. 18A, which has just been described.

Table showing Results of Application of B. Typhi abdominalis, in Single Doses, to Filters Nos. 35 and 36.

Date — 1892.	Filter No. 35 (intermittent). Rate of Filtration. Gallons per Acre Daily.	Filter No. 35 (intermittent). Per Cent. of Applied Bacteria which appeared in Effluent.	Date — 1892.	Filter No. 36 (continuous). Rate of Filtration. Gallons per Acre Daily.	Filter No. 36 (continuous). Per Cent. of Applied Bacteria which appeared in Effluent.
February 24, ...	340,000	0	February 24, ...	460,000	0
March 2, ...	320,000	0	March 2, ...	400,000	0
March 10, ...	280,000	0	March 10, ...	400,000	0

All the rates were the maximum quantity of water which could be made to pass the filters. The results of these experiments and of the daily examinations indicated that these filters removed all or very nearly all of the bacteria in the applied water. The quantity of water which they could filter, although greater than that for No. 8, was still too small for economic filtration on a large scale. It was therefore decided to discontinue these filters and devote our attention to the study of filters which could purify a larger quantity of water. In digging out the sand it was found that there was an accumulation of the finer particles in the upper portion of the filter. This was due to throwing the material into water in the process of construction and was the reason why so little water could pass the filters. The later filters were all filled dry and stratification was avoided.

Monthly Averages of Analyses of Effluent of Filter No. 33.

[This filter was operated intermittently.]

[Parts per 100,000.]

Month.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Degrees F. Applied Water.	Temperature. Degrees F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Dec. 16-31, . .	280,000	41°	43°	.00	.0015	.0027	.29	.0270	.0000	.02	119
1892.											
January, . .	380,000	36°	42°	.00	.0010	.0024	.17	.0188	.0003	.01	6
February, . .	360,000	37°	40°	.00	.0026	.0030	.21	.0202	.0002	.02	3
March, . . .	320,000	38°	41°	.00	.0039	.0028	.20	.0266	.0000	.03	7
April, . . .	320,000	51°	50°	.00	.0033	.0027	.15	.0282	.0001	.00	3

Monthly Averages of Analyses of Effluent of Filter No. 34.

[This filter was operated continuously.]

[Parts per 100,000.]

Month.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F. Applied Water.	Temperature. Degrees F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
Dec. 16-31, . .	1,040,000	41°	44°	.00	.0017	.0034	.36	.0365	.0005	.02	228
1892.											
January, . .	520,000	36°	42°	.00	.0019	.0028	.16	.0177	.0002	.02	36
February, . .	340,000	37°	41°	.00	.0039	.0028	.21	.0210	.0001	.02	8
March, . . .	320,000	38°	41°	.00	.0052	.0034	.21	.0290	.0000	.02	8
April, . . .	380,000	51°	50°	.00	.0034	.0041	.16	.0250	.0000	.00	8

Monthly Averages of Analyses of Effluent of Filter No. 35.

[This filter was operated intermittently.]

[Parts per 100,000.]

Month.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F. Applied Water.	Temperature. Degrees F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
December 16-31, .	560,000	41°	48°	.00	.0040	.0020	.42	.0320	.0003	.02	76
1892.											
January, . .	500,000	36°	52°	.00	.0019	.0025	.16	.0180	.0001	.02	1
February, . .	360,000	37°	53°	.00	.0026	.0033	.21	.0257	.0001	.02	6
March, . . .	240,000	38°	47°	.00	.0024	.0033	.20	.0330	.0001	.02	1

Monthly Averages of Analyses of Effluent of Filter No. 36.

[This filter was operated continuously.]

[Parts per 100,000.]

Month.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F. Applied Water.	Temperature. Degrees F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1891.											
December 16-31, .	540,000	41°	47°	.00	.0097	.0030	.40	.0320	.0002	.02	42
1892.											
January, . .	540,000	36°	52°	.00	.0030	.0028	.16	.0220	.0002	.02	1
February, . .	400,000	37°	53°	.01	.0031	.0039	.22	.0287	.0000	.02	4
March, . . .	380,000	38°	47°	.00	.0016	.0026	.21	.0307	.0001	.02	1

Filter No. 33A.

This filter was started on April 28 and contained five feet of sand of an effective size of 0.14 millimeter. It was operated continuously. The water was applied in excess at the top, the surplus passing off through an overflow, and the rate of filtration was controlled below at the faucet, to which a trap was attached. The tables on page 478, containing the averages of the results of the chemical and bacterial analyses, together with the tables of daily observation, pages 498–504, show the changes in the rates of filtration, and in the acting pressure. The other conditions were as nearly constant as possible throughout the year. In July and August the bacteria appeared to grow in the filter. This subject is discussed on page 530. During December the cold weather interfered somewhat with the operation of the experimental filter. This is explained as follows: When wet sand in an iron tank of small diameter freezes it expands while the galvanized iron at the same time contracts. Upon subsequent thawing the sand contracts and the iron expands, causing channels to be formed at the sides. This took place to a greater or less extent in the case of all the small filters, and the results obtained in December have not for this reason been included in the discussion.

The amount of albuminoid ammonia stored between successive scrapings, October 7 to 29, was 43 per cent. of that in the water applied during this time. This filter was scraped on May 23, July 7 and 30, August 10 and 31, September 19, October 7 and 29, December 12, 22 and 29.

Table showing the Results of Application of Bacteria, in Single Doses, to Filter No. 33 A.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
May 2, ...	2,020,000	B. prodigiosus, .	0
May 5, ...	1,780,000	B. coli communis,	0

The averages of the daily bacterial results upon this filter, arranged in periods, are given in the following table : —

Bacterial Results, Filter No. 33 A.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number Applied which Appeared in Effluent.	
		Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
June,	2,000,000	5,390	0	12	0	0.22	-
July,	2,000,000	4,300	0	73	0	1.70	-
August,	2,000,000	5,030	0	40	0	0.79	-
September 1-15,	2,000,000	8,050	0	26	0	0.32	-
September 16-October 7,	2,000,000	18,500	4,160	61	1.60	0.33	0.04
October 8-November 16,	2,000,000	12,700	0	51	0	0.41	-
November 17-December 12,	500,000	4,900	7,600	63	0.16	1.21	0.002
December 13-24,	3,000,000	5,750	5,360	274	34.00	4.76	0.63

Monthly Averages of Analyses of Effluent of Filter No. 33 A.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	1,840,000	57°	56°	.13	.0024	.0059	.12	.0148	.0002	.21	131
June,	2,180,000	72°	71°	.18	.0014	.0059	.16	.0320	.0002	.20	12
July,	1,880,000	76°	73°	.26	.0006	.0081	.14	.0205	.0000	.36	73
August,	2,000,000	74°	72°	.24	.0006	.0077	.19	.0203	.0000	.29	40
September,	1,980,000	66°	65°	.25	.0007	.0075	.21	.0265	.0000	.29	51
October,	2,000,000	56°	56°	.21	.0005	.0077	.27	.0285	.0000	.20	50
November,	1,260,000	43°	47°	.29	.0005	.0074	.19	.0460	.0000	.27	71
December,	1,680,000	36°	40°	.33	.0004	.0066	.19	.0290	.0000	.33	162

Filter No. 34 A.

This filter was constructed April 28 of fine sand, five feet in depth, of an effective size of 0.09 millimeter and has been operated continuously. The rate of filtration up to November 1 was 2,000,000 gallons per acre daily. The following tables show a summary of the data, and the daily results after June 1 are presented on pages 498–504. The bacterial growths during July and August, and the effect of freezing weather in December, are discussed on pages 530 and 477 respectively. This filter was scraped on May 23, June 20 and 28, July 7, 23 and 30, August 10, 17 and 26, September 8, 19 and 28, October 3 and 21, November 11, December 12, 20 and 29.

Table showing the Results of Application of Bacteria, in Single Doses, to Filter No. 34 A.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
May 2,	2,020,000	B. prodigiosus,	0
May 5,	1,900,000	B. coli communis,	0

The following table contains the averages of the results of the daily bacterial examinations, arranged in periods: —

Bacterial Results, Filter No. 34 A.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number Applied which appeared in Effluent.	
		Water Bacteria.	Bacillus Prodiglosus.	Water Bacteria.	Bacillus Prodiglosus.	Water Bacteria.	Bacillus Prodiglosus.
June,	2,000,000	5,388	0	10	0	0.18	-
July,	2,000,000	4,170	0	26	0	0.62	-
August,	2,000,000	5,030	0	82	0	1.63	-
September 1-15,	2,000,000	8,050	0	17	0	0.21	-
September 16-October 7,	2,000,000	18,500	4,160	35	0.72	0.19	0.02
October 8-31,	2,000,000	10,370	0	24	0	0.23	-
November 1-15,	1,000,000	16,900	13,400	25	0.62	0.15	0.005
November 16-December 12,	500,000	4,900	7,600	13	0.11	0.26	0.001
December 13-24,	3,000,000	5,750	5,360	537	35.00	9.29	0.65

Monthly Averages of Analyses of Effluent of Filter No. 34 A.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	2,000,000	57°	56°	.13	.0028	.0064	.12	.0128	.0004	.22	71
June,	1,880,000	72°	71°	.21	.0013	.0074	.16	.0230	.0000	.25	10
July,	1,800,000	76°	73°	.25	.0013	.0072	.12	.0260	.0000	.33	26
August,	2,000,000	74°	73°	.25	.0006	.0086	.21	.0223	.0000	.30	82
September,	1,900,000	66°	65°	.23	.0007	.0076	.21	.0255	.0000	.33	24
October,	1,920,000	56°	55°	.20	.0006	.0087	.27	.0240	.0000	.21	29
November,	720,000	43°	46°	.33	.0004	.0072	.19	.0285	.0000	.34	19
December,	1,640,000	36°	40°	.32	.0010	.0078	.19	.0250	.0000	.35	136

Filter No. 35 A.

This intermittent filter was started on March 30 and contained fifty-seven and a half inches of sand of an effective size of 0.20 millimeter. One foot below the surface there was one inch of loam. The faucet was kept wide open and the rate of filtration regulated at the top of the filter. From May 2 to June 4 inclusive the water was applied in one-half gallon doses from a reservoir with a siphon attachment. These small doses were applied at frequent intervals during the entire twenty-four hours. During the remainder of the year the water was applied during sixteen hours a day six days a week and the filter allowed to drain during the remaining hours. The filter was scraped on May 23, July 7, August 6 and 31, September 19, October 8, November 4 and 16, and December 9.

The bacterial growths during July and August, and the effect of freezing weather in December, are discussed on pages 530 and 477 respectively.

Table showing the Results of Application of Bacteria, in Single Doses, to Filter No. 35 A.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which Appeared in Effluent.
April 1,	860,000	B. prodigiosus,	0
12,	1,560,000	B. typhosus,	0
15,	2,140,000	B. typhosus,	0
26,	2,740,000	B. typhosus,	1.6
28,	2,600,000	B. coli communis,	12.7 (?)
May 11,	2,380,000	B. coli communis,	1.4
19,	1,740,000	B. prodigiosus,	0
25,	1,540,000	B. typhosus,	0.16

The following table contains the averages of the results of the daily bacterial examinations, arranged in periods: —

Bacterial Results, Filter No. 35 A.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number Applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,000,000	5,390	0	12	0	0.22	-
July,	1,000,000	4,300	0	24	0	0.56	-
August,	1,000,000	5,030	0	37	0	0.74	-
September 1-15,	1,500,000	8,050	0	95	0	1.08	-
September 16-October 7,	1,500,000	18,500	4,160	105	2.95	0.57	0.07
October 8-31,	1,500,000	10,370	0	52	0	0.50	-
November 1-16,	1,000,000	16,900	13,400	38	3.80	0.22	0.03
November 17-December 31,	1,000,000	5,970	0	31	0	0.52	-

Monthly Averages of Analyses of Effluent of Filter No. 35 A.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
April,	1,500,000	51°	45°	.02	.0041	.0055	.16	.0080	.0001	.06	590
May,	1,760,000	57°	56°	.16	.0046	.0072	.12	.0146	.0002	.26	31
June,	1,340,000	72°	74°	.20	.0015	.0078	.17	.0295	.0001	.24	12
July,	980,000	76°	69°	.16	.0005	.0062	.14	.0825	.0000	.22	24
August,	960,000	74°	69°	.15	.0006	.0067	.24	.0997	.0001	.18	37
September,	1,300,000	66°	67°	.21	.0004	.0076	.20	.0310	.0000	.31	98
October,	1,680,000	56°	52°	.20	.0009	.0101	.27	.0245	.0000	.20	67
November,	1,040,000	43°	49°	.32	.0012	.0082	.19	.0205	.0000	.29	39
December,	860,000	36°	39°	.30	.0002	.0073	.19	.0225	.0000	.32	25

Filter No. 36 A.

This is a duplicate of Filter No. 35 A. The depth of sand was fifty-eight inches when the filter was started on March 30. The loam layer was one inch deep and placed one foot below the surface. The filter was operated continuously. The rate of filtration was regulated at the faucet, to which a trap was attached. For dis-

cussion of bacterial growths during warm weather and the effect of freezing see pages 530 and 477 respectively. This filter was scraped on May 23, July 7, August 16, September 19, November 1, 11 and 21, December 5 and 26.

Table showing Results of Application of Bacteria, in Single Doses, to Filter No. 36 A.

DATE — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
March 31,	980,000	B. prodigiosus,	0
April 11,	1,540,000	B. typhi abdom.,	0
26,	2,100,000	B. typhi abdom.,	2.78
28,	1,940,000	B. coli communis,	1.55
May 11,	2,000,000	B. coli communis,	0.25
19,	1,940,000	B. prodigiosus,	0
25,	1,540,000	B. typhi abdom.,	0.14

The following table contains the averages, by periods, of the results of the daily bacterial examinations : —

Bacterial Results, Filter No. 36 A.

DATE — 1892.	Rate of Filtration. — Gallons per Acre Daily.	BACTERIA PER CUBIC CENTIMETER IN APPLIED WATER.		BACTERIA PER CUBIC CENTIMETER IN EFFLUENT.		PER CENT. OF NUMBER APPLIED WHICH APPEARED IN EFFLUENT.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,500,000	5,390	0	12	0	0.22	-
July,	1,500,000	4,300	0	53	0	1.23	-
August,	1,500,000	5,030	0	87	0	1.73	-
September 1-15,	1,500,000	8,050	0	22	0	0.27	-
September 16-October 7,	1,500,000	18,500	4,160	74	1.86	0.40	0.04
October 8-31,	1,500,000	10,370	0	33	0	0.32	-
November 1-December 11,	3,000,000	9,260	9,790	42	4.80	0.45	0.05
December 12-31,	2,000,000	7,190	4,710	87	3.50	1.21	0.03

Monthly Averages of Analyses of Effluent of Filter No. 36 A.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
April, . . .	1,600,000	51°	47°	.01	.0040	.0041	.15	.0102	.0002	.05	19
May, . . .	1,900,000	57°	56°	.17	.0035	.0075	.12	.0154	.0000	.26	24
June, . . .	1,460,000	72°	74°	.20	.0008	.0065	.14	.0235	.0002	.26	12
July, . . .	1,520,000	76°	74°	.21	.0005	.0072	.13	.0235	.0000	.32	53
August, . . .	1,520,000	74°	70°	.24	.0010	.0097	.20	.0223	.0004	.28	87
September, . .	1,480,000	66°	62°	.24	.0010	.0079	.19	.0250	.0000	.35	46
October, . . .	1,540,000	56°	53°	.18	.0006	.0079	.27	.0295	.0000	.20	41
November, . .	2,940,000	43°	47°	.42	.0022	.0086	.19	.0190	.0000	.43	51
December, . .	2,060,000	36°	38°	.36	.0019	.0080	.18	.0225	.0000	.37	18

Filter No. 37.

This filter was constructed on April 18 and contained sand sixty-one inches deep and of an effective size of 0.20 millimeter. It was operated continuously and the rate was regulated at the faucet, to which was attached a trap. The filter was scraped on the following dates: May 23, July 26, September 16, October 7 and 26, and November 28. In regard to bacterial growths in summer and effect of freezing weather see pages 530 and 477 respectively.

Table showing Results of Application of Bacteria, in Single Doses, to Filter No. 37.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
April 26, ...	900,000	B. prodigiosus, .	0
27, ...	800,000	B. prodigiosus, .	0
May 2, ...	1,480,000	B. prodigiosus, .	0
5, ...	1,600,000	B. coli communis,	0.008
11, ...	1,400,000	B. coli communis,	0
19, ...	1,540,009	B. prodigiosus, .	0
25, ...	1,540,000	B. typhi abdom.,	0

The following table contains the averages, by periods, of the results of the daily bacterial examinations: —

Bacterial Results, Filter No. 37.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in the Effluent.		Per Cent. of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,500,000	5,390	0	13	0	0.24	-
July,	1,500,000	4,300	0	53	0	1.23	-
August,	1,500,000	5,030	0	96	0	1.91	-
September 1-15,	1,500,000	8,050	0	14	0	0.17	-
September 16-October 7,	1,500,000	18,500	4,175	53	0.61	0.28	0.01
October 8-31,	2,000,000	10,370	2,560	43	2.95	0.41	0.11
November 1-30,	2,000,000	11,160	0	32	0	0.29	-
December 1-31,	2,000,000	5,540	0	47	0	0.85	-

Monthly Averages of Analyses of Effluent of Filter No. 37.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
April,	1,000,000	51°	47°	.01	.0223	.0086	.19	.0125	.0004	.00	175
May,	1,420,000	57°	59°	.08	.0035	.0056	.12	.0126	.0002	.16	48
June,	1,460,000	72°	77°	.21	.0006	.0065	.16	.0195	.0002	.28	13
July,	1,360,000	76°	73°	.19	.0006	.0069	.12	.0215	.0000	.27	53
August,	1,440,000	74°	71°	.22	.0006	.0076	.20	.0223	.0000	.25	96
September,	1,480,000	66°	64°	.23	.0007	.0069	.19	.0260	.0000	.33	75
October,	1,900,000	56°	52°	.17	.0005	.0075	.27	.0215	.0000	.19	44
November,	2,020,000	43°	47°	.38	.0010	.0073	.19	.0225	.0000	.37	32
December,	1,700,000	36°	37°	.34	.0015	.0072	.18	.0165	.0000	.36	48

Filter No. 38.

This filter was started April 28 and contained twenty-four inches of sand of an effective size of 0.20 millimeter. It was operated continuously and was regulated and trapped below in the usual manner. In regard to bacterial growths in summer and the effect of freezing weather see pages 530 and 477 respectively. The filter was scraped on May 23, July 14 and 30, August 23, September 9 and 19, October 11 and 22, November 7, 19 and 28, and December 6.

Table showing the Results of Application of Bacteria, in Single Doses, to Filter No. 38.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
May 3,	1,020,000	B. prodigiosus,	0
5,	960,000	B. coli communis,	0
11,	940,000	B. coli communis,	0.15
19,	1,540,000	B. prodigiosus,	0
25,	1,500,000	B. typhi abdom.,	0.84

The following table contains the averages, by periods, of the results of the daily bacterial examinations : —

Bacterial Results, Filter No. 38.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,500,000	5,390	0	41	0	0.76	-
July,	1,500,000	4,300	0	64	0	1.49	-
August,	1,500,000	5,030	0	67	0	1.33	-
September 1-15,	1,500,000	8,050	0	49	0	0.61	-
September 16-October 7,	1,500,000	18,500	4,175	106	5.51	0.57	0.13
October 8-31,	2,000,000	10,370	2,560	58	1.99	0.56	0.07
November 1-21,	2,000,000	14,670	0	52	0	0.36	-
November 22-December 12,	3,000,000	4,400	7,360	87	24.40	1.98	0.33
December 13-31,	500,000	7,190	4,710	72	0.63	1.00	0.01

Monthly Averages of Analyses of Effluent of Filter No. 38.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	1,380,000	57°	55°	.14	.0048	.0066	.12	.0102	.0002	.23	309
June,	1,440,000	72°	69°	.27	.0026	.0077	.14	.0193	.0000	.37	41
July,	1,400,000	76°	70°	.33	.0010	.0092	.14	.0200	.0000	.39	64
August,	1,540,000	74°	70°	.35	.0011	.0099	.19	.0213	.0000	.45	49
September,	1,480,000	66°	63°	.28	.0006	.0093	.20	.0225	.0000	.38	70
October,	1,900,000	56°	54°	.24	.0012	.0088	.27	.0245	.0000	.24	74
November,	2,240,000	43°	42°	.47	.0006	.0113	.19	.0220	.0000	.46	50
December,	1,380,000	36°	38°	.34	.0026	.0080	.18	.0270	.0000	.35	91

Filter No. 39.

This filter was started April 28 and contained twelve inches of sand of an effective size of 0.20 millimeter. It was operated continuously in the usual manner. In regard to bacterial growths in summer and the effect of freezing weather see pages 530 and 477 respectively. The filter was scraped May 23, June 14 and 25, July 6, 14, 23 and 30, August 2, 10, 18, 26 and 31, September 9, 19 and 27, October 6 and 21, November 5, 12, 18, 22 and 28, December 5 and 10.

Table showing Results of Application of Bacteria, in Single Doses, to Filter No. 39.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
May 3,	1,060,000	B. prodigiosus,	0
5,	1,000,000	B. coli communis,	0.12
11,	960,000	B. coli communis,	4.65 (?)
19,	1,580,000	B. prodigiosus,	0.40
25,	1,540,000	B. typhi abdom.,	1.00
July 28,	1,900,000	B. prodigiosus,*	0.13
August 4,	1,950,000	B. typhi abdom.,*	0.06

* Applied once in two hours for ten hours.

The following table contains the averages, by periods, of the results of the daily bacterial examinations: —

Bacterial Results, Filter No. 39.

Date — 1892.	Rate of Filtration. Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June 1-July 11,	1,500,000	4,560	0	65	0	1.42	–
July 12-31,	2,000,000	5,430	0	42	0	0.77	–
August,	2,000,000	5,030	0	61	0	1.21	–
September 1-15,	2,000,000	8,050	0	48	0	0.59	–
September 16-30,	2,000,000	17,070	4,530	96	4.96	0.56	0.11
October,	1,000,000	12,910	2,570	45	1.75	0.35	0.07
November 1-21,	2,000,000	14,670	12,210	77	6.76	0.52	0.05
November 22-December 12,	3,000,000	4,400	7,360	125	42.90	2.94	0.58
December 13-31,	500,000	7,190	4,600	52	0.75	0.72	0.01

Monthly Averages of Analyses of Effluent of Filter No. 39.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May, . . .	1,400,000	57°	56°	.25	.0048	.0068	.11	.0120	.0004	.29	753
June, . . .	1,300,000	72°	70°	.34	.0024	.0081	.14	.0187	.0000	.42	66
July, . . .	1,700,000	76°	70°	.35	.0012	.0097	.14	.0225	.0000	.40	48
August, . . .	1,980,000	74°	70°	.38	.0023	.0114	.18	.0207	.0000	.46	61
September, . .	1,900,000	66°	64°	.29	.0006	.0098	.21	.0195	.0000	.37	73
October, . . .	1,120,000	56°	53°	.22	.0007	.0085	.27	.0265	.0000	.23	45
November, . .	2,240,000	43°	42°	.25	.0027	.0132	.19	.0170	.0000	.52	85
December, . .	1,360,000	36°	36°	.38	.0066	.0091	.20	.0165	.0000	.40	89

Filter No. 40.

This filter, twelve inches deep, was constructed April 28 with sand of effective size of 0.20 millimeter and contained a layer of loam one inch in depth, eleven inches below the surface. It was operated continuously in the usual manner. For discussion of bacterial growths during the summer months see page 530. The dates of scraping were May 23, June 11, 24 and 30, July 14 and 30, August 2 and 23, September 9 and 26, October 6, 15 and 26. The filter was discontinued October 26.

Table showing Results of Application of Bacteria, in Single Doses, to Filter No. 40.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Species of Bacteria Applied.	Per Cent. of Applied Bacteria which appeared in Effluent.
May 3, ...	980,000	B. prodigiosus, .	0
5, ...	1,020,000	B. coli communis,	0.002
11, ...	960,000	B. coli communis,	9.14 (?)
19, ...	2,120,000	B. prodigiosus, .	0.27
25, ...	1,480,000	B. typhi abdom., .	1.56
July 28, ...	960,000	B. prodigiosus,* .	0.02
August 4, ...	1,020,000	B. typhi abdom.,*	0.01

* Applied once in two hours for ten hours.

The following table contains the averages, by periods, of the results of the daily bacterial examinations: —

Bacterial Results, Filter No. 40.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June 1-July 11,	1,500,000	4,560	0	44	0	0.96	-
July 12-31,	1,000,000	5,430	0	52	0	0.96	-
August,	1,000,000	5,030	0	82	0	1.63	-
September 1-15,	1,000,000	8,050	0	47	0	0.58	-
September 16-30,	1,000,000	17,070	4,530	39	4.91	0.23	0.11
October 1-26,	2,000,000	13,950	2,740	37	1.60	0.27	0.06

Monthly Averages of Analyses of Effluent of Filter No. 40.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	1,620,000	57°	55°	.20	.0045	.0069	.12	.0115	.0003	.25	316
June,	1,420,000	72°	70°	.27	.0029	.0073	.13	.0180	.0001	.37	56
July,	1,080,000	76°	70°	.34	.0007	.0088	.13	.0200	.0000	.39	45
August,	1,000,000	74°	69°	.36	.0037	.0105	.19	.0217	.0001	.40	82
September,	980,000	66°	63°	.29	.0015	.0094	.21	.0205	.0000	.39	43
October,	1,940,000	56°	53°	.22	.0017	.0079	.27	.0305	.0001	.22	37

Filter No. 41.

This (intermittent) filter, sixty inches deep, was constructed on May 9 and contained sand of an effective size of 0.14 millimeter (the same as in No. 33 A), with a layer of loam three and one-half inches thick and nine inches below the surface. Water was applied about fifteen hours a day six days in a week, and the filter allowed to drain for the rest of the time. The faucet had no trap attached and was kept wide open. The rate of filtration was regulated at the top of filter. The maximum rate of filtration gradually decreased, due

to sub-surface clogging, and the layer of loam was removed on November 30. The filter was scraped on May 23, July 7, August 6 and 31, September 19, October 1, 15 and 26, November 15 and 30.

The question of bacterial growth during the summer months and the effect of freezing weather are discussed on pages 530 and 477 respectively.

The following table contains the averages, by periods, of the results of the daily bacterial examinations: —

Bacterial Results, Filter No. 41.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent. of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
June,	1,500,000	5,380	0	31	0	0.58	-
July,	1,500,000	3,940	0	39	0	0.99	-
August,	1,500,000	5,030	0	55	0	1.09	-
September 1-15,	1,500,000	17,070	0	38	0	0.22	-
September 16-October 7,	1,500,000	18,500	4,175	28	1.43	0.15	0.03
October 8-31,	1,500,000	10,370	0	27	0	0.26	-
November 1-December 6,	1,000,000	10,040	0	15	0	0.15	-
December 7-31,	2,000,000	7,520	5,180	730	48	9.71	0.92

Monthly Averages of Analyses of Effluent of Filter No. 41.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May,	1,600,000	57°	58°	.06	.0053	.0048	.23	.0132	.0006	.12	929
June,	1,480,000	72°	71°	.15	.0013	.0068	.16	.0190	.0004	.23	31
July,	1,280,000	76°	70°	.12	.0005	.0061	.12	.0575	.0000	.20	39
August,	1,240,000	74°	70°	.16	.0007	.0065	.21	.0757	.0000	.21	55
September,	1,560,000	66°	62°	.22	.0008	.0080	.21	.0320	.0000	.31	33
October,	1,580,000	56°	53°	.19	.0012	.0083	.27	.0245	.0000	.19	26
November,	1,080,000	43°	48°	.32	.0005	.0080	.19	.0210	.0000	.32	15
December,	1,840,000	36°	39°	.36	.0012	.0092	.18	.0215	.0000	.37	724

Filter No. 42.

This filter was started on October 29 and contained thirteen inches of sand of an effective size of 0.20 millimeter. It was operated continuously in the usual manner. The dates of scraping were November 10, 18 and 28, December 6 and 10. See page 477 in regard to effect of freezing weather.

The following table contains the averages, by periods, of the results of the daily bacterial examinations : —

Bacterial Results, Filter No. 42.

Date — 1892.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.		Bacteria per Cubic Centimeter in Effluent.		Per Cent of Number applied which appeared in Effluent.	
		Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.	Water Bacteria.	Bacillus prodigiosus.
November 1-22, . . .	2,000,000	14,670	12,210	198	17.40	1.35	0.14
November 23-December 12,	3,000,000	4,400	7,360	207	44.50	4.70	0.60
December 13-31, . . .	500,000	7,190	4,600	38	0.51	0.53	0.01

Monthly Averages of Analyses of Effluent of Filter No. 42.

[Parts per 100,000.]

Date — 1892.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
November, . .	2,220,000	43°	44°	.33	.0055	.0106	.23	.0133	.0001	.35	236
December, . .	1,400,000	36°	36°	.38	.0098	.0111	.20	.0155	.0000	.38	70

Statistics of the Work of the Sand Filters used in Experiments upon the Purification of Water during 1892.

The rates of filtration, the loss of head in continuous filters and the results of the bacterial examinations of the river water before and after passage through the several filters are given in the following tables for each day, beginning June 1. The filters were scraped on those dates on which the results are underlined. In all of these tables the figures given are for the twenty-four hours ending at 9 A.M. An explanation of many of the observations recorded will be found under the head of "Special Biological Work" beyond (p. 526).

Filters Nos. 18 A and 41.

[These filters were both operated intermittently.]

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 18A.		Filter No. 41.	
		Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.
June 1,	500	1,480,000	-	1,960,000	-
2,	6,500	1,920,000	11	1,980,000	-
3,	1,800	1,140,000	-	1,840,000	-
4,	2,100	1,260,000	-	2,020,000	-
5,	2,700	960,000	-	1,700,000	-
6,	-	1,020,000	-	380,000	-
7,	1,100	1,080,000	-	2,160,000	-
8,	5,200	1,040,000	-	2,020,000	132
9,	4,500	1,080,000	3	1,880,000	36
10,	4,400	1,300,000	-	2,160,000	15
11,	4,000	840,000	-	1,960,000	9
12,	3,500	820,000	-	1,580,000	36
13,	-	280,000	-	80,000	-
14,	1,300	1,340,000	-	2,440,000	-
15,	12,600	1,000,000	-	800,000	14
16,	2,600	920,000	-	2,200,000	4
17,	18,000	1,840,000	-	1,400,000	29
18,	14,500	960,000	-	1,020,000	77
19,	17,100	1,020,000	-	2,000,000	19
20,	-	1,240,000	-	360,000	-
21,	1,000	820,000	-	2,780,000	-
22,	11,700	1,320,000	-	2,120,000	50
23,	3,700	1,040,000	8	1,900,000	5
24,	2,700	1,180,000	-	1,940,000	31
25,	2,700	1,120,000	-	1,840,000	17
26,	2,600	1,160,000	-	1,520,000	20
27,	-	1,360,000	-	400,000	-
28,	2,700	1,100,000	-	880,000	-
29,	9,200	1,000,000	-	520,000	17
30,	1,300	1,000,000	-	880,000	9

Filters Nos. 18 A and 41 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 18 A.		Filter No. 41.	
		Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.
July 1,	500	920,000	-	460,000	12
2,	1,300	800,000	-	360,000	4
3,	3,900	860,000	-	860,000	78
4,	-	0	-	160,000	-
5,	-	60,000	-	0	-
6,	2,500	860,000	-	140,000	-
7,	1,300	800,000	6	340,000	1
8,	800	1,000,000	-	2,000,000	6
9,	1,600	1,020,000	-	1,980,000	17
10,	3,000	960,000	-	760,000	212
11,	-	620,000	-	280,000	-
12,	800	1,220,000	-	1,680,000	-
13,	6,100	1,020,000	-	2,080,000	4
14,	9,300	1,000,000	-	2,160,000	26
15,	21,900	1,060,000	-	2,100,000	16
16,	8,200	1,100,000	-	1,880,000	22
17,	6,000	940,000	-	200,000	20
18,	-	800,000	-	60,000	-
19,	500	1,220,000	-	2,040,000	-
20,	1,000	1,180,000	-	1,920,000	14
21,	4,700	1,020,000	7	1,300,000	14
22,	16,900	1,060,000	-	1,780,000	144
23,	6,500	1,020,000	-	1,840,000	19
24,	5,500	1,240,000	-	2,260,000	18
25,	-	540,000	-	400,000	-
26,	1,300	420,000	-	2,500,000	-
27,	1,100	1,380,000	-	2,080,000	57
28,	2,200	1,040,000	-	2,000,000	49
29,	3,500	1,000,000	-	2,120,000	47
30,	1,000	920,000	-	1,940,000	65
31,	1,200	900,000	-	200,000	16

City water was applied to filters instead of river water July 9, 12 M., to July 11, 9 A.M.; July 16, 2 P.M., to July 18, 10 A.M.; July 30, 2.15 P.M., to August 1, 8.50 A.M.

Filters Nos. 18 A and 41 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 18 A.		Filter No. 41.	
		Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.
August 1,	-	160,000	-	20,000	-
2,	500	1,100,000	-	2,000,000	-
3,	650	1,000,000	-	1,860,000	35
4,	12,000	1,120,000	7	1,780,000	61
5,	-	1,320,000	-	1,440,000	41
6,	6,000	980,000	-	2,160,000	20
7,	2,000	940,000	-	160,000	200
8,	-	1,160,000	-	40,000	-
9,	1,600	1,000,000	-	1,900,000	-
10,	2,200	1,040,000	-	2,080,000	85
11,	5,600	1,100,000	-	2,180,000	37
12,	1,900	1,380,000	-	2,200,000	32
13,	2,000	1,160,000	-	1,980,000	22
14,	2,800	1,020,000	-	200,000	17
15,	-	920,000	-	20,000	-
16,	1,000	980,000	-	2,040,000	-
17,	3,000	1,000,000	-	1,900,000	3
18,	6,700	1,260,000	32	2,100,000	27
19,	1,200	1,220,000	64	2,220,000	829*
20,	15,600	980,000	31	2,040,000	32
21,	7,100	800,000	24	220,000	162
22,	-	560,000	-	40,000	-
23,	2,400	1,040,000	48	1,640,000	-
24,	10,500	940,000	17	2,100,000	32
25,	8,000	1,040,000	53	2,100,000	61
26,	5,900	1,080,000	63	1,920,000	85
27,	7,600	1,380,000	130	1,900,000	47
28,	-	980,000	-	320,000	15
29,	-	1,440,000	50	20,000	-
30,	11,400	1,100,000	24	220,000	-
31,	3,100	1,100,000	-	540,000	77

* Numbers over 500 do not appear in the averages (see page 530).

City waterw as applied to filter instead of river water August 6, 2 P.M., to August 8, 8 A.M.; August 13, 2.15 P.M., to August 15, 9 A.M.; August 20, 2 P.M., to August 22, 9.30 A.M.; August 27, 2 P.M., to August 29, 9.30 A.M.

Filters Nos. 18 A and 41 — Continued.

Date — 1892.	Bacteria Per Cubic Centimeter in Applied Water.	Filter No. 18 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 18 A. Bacteria per Cubic Centimeter in Effluent.	Filter No. 41. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 41. Bacteria per Cubic Centimeter in Effluent.
September 1,	1,500	760,000	260	1,980,000	29
2,	1,700	900,000	140	2,000,000	46
3,	2,900	1,040,000	120	2,280,000	35
4,	8,800	1,020,000	40	300,000	25
5,	-	1,000,000	-	20,000	-
6,	-	1,060,000	-	0	-
7,	1,800	940,000	27	2,480,000	-
8,	16,200	1,180,000	25	2,620,000	30
9,	18,700	1,160,000	38	2,760,000	96
10,	7,900	1,060,000	50	2,700,000	50
11,	12,800	940,000	20	2,460,000	16
12,	-	1,100,000	-	300,000	-
13,	6,000	740,000	52	2,100,000	-
14,	7,500	740,000	38	2,380,000	16
15,	10,800	920,000	67	2,480,000	-

City water was applied instead of river water September 3, 2.30 P.M., to September 6, 8 A.M.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 18 A.			Filter No. 41.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
September 16,	-	0	940,000	-	-	320,000	-	-
17,	18,200	1,000	1,020,000	121	0.00	1,700,000	17	0.00
18,	4,400	350	1,120,000	78	0.00	880,000	14	0.00
19,	-	0	900,000	-	-	80,000	-	-
20,	1,400	2,000	820,000	36	0.50	2,100,000	41	0.00
21,	6,600	7,500	1,000,000	55	18.00	1,640,000	9	1.25
22,	23,000	7,500	1,080,000	63	9.00	1,400,000	55	3.00
23,	23,000	6,800	1,180,000	56	13.00	2,140,000	28	2.25
24,	5,200	8,300	920,000	82	6.50	1,700,000	17	2.75
25,	19,000	6,500	1,060,000	186	1.75	2,160,000	70	1.50
26,	-	0	1,000,000	-	-	80,000	-	-
27,	6,000	3,000	1,300,000	37	3.75	1,620,000	25	0.25
28,	8,000	4,000	780,000	83	9.00	1,160,000	22	0.80
29,	46,000	5,300	1,200,000	494	10.00	1,460,000	24	0.50
30,	44,000	2,200	1,060,000	1,076*	5.00	1,560,000	20	1.50

* Numbers over 500 do not appear in the averages (see page 530).

For method of application see page 529. City water was applied instead of river water September 25, 8.45 A.M., to September 26, 9 A.M.

Filters Nos. 18 A and 41 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 18 A.			Filter No. 41.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. — Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. — Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. — Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. — Bacillus Prodigiosus.
October 1, ...	44,000	2,500	1,200,000	690	9.00	1,140,000	27	0
2, ...	28,000	2,700	880,000	387	6.00	1,760,000	17	2.00
3, ...	-	0	700,000	-	-	800,000	-	-
4, ...	18,000	3,700	1,360,000	170	7.00	1,760,000	45	0.75
5, ...	14,000	3,200	1,320,000	167	3.75	2,160,000	20	1.00
6, ...	23,000	4,600	1,220,000	157	12.00	2,400,000	24	5.00
7, ...	1,300	4,000	720,000	206	2.00	1,660,000	28	3.25
8, ...	19,600	2,400	1,740,000	204	19.00	2,560,000	30	0
9, ...	14,000	3,000	1,560,000	159	11.20	1,580,000	58	0
10, ...	-	0	1,500,000	-	-	40,000	-	-
11, ...	10,000	1,500	1,600,000	68	5.00	2,020,000	-	-
12, ...	11,000	2,800	1,720,000	144	3.50	1,840,000	21	0
13, ...	10,000	1,000	1,600,000	180	5.20	1,680,000	22	0
14, ...	11,000	500	1,540,000	68	3.50	1,980,000	28	0
15, ...	21,000	350	1,560,000	75	1.30	1,320,000	32	0
16, ...	18,000	3,500	1,680,000	69	1.00	1,840,000	47	0
17, ...	-	0	2,040,000	-	-	760,000	-	-
18, ...	15,000	1,000	1,320,000	53	1.30	1,300,000	-	-
19, ...	4,100	2,200	1,820,000	23	0.80	2,080,000	4	0
20, ...	10,000	5,000	1,280,000	14	0.80	2,060,000	102	0
21, ...	4,200	1,700	1,340,000	16	0.00	2,080,000	18	0
22, ...	5,000	670	1,940,000	21	1.30	2,040,000	15	0
23, ...	16,000	3,300	1,640,000	58	1.30	1,700,000	20	0
24, ...	-	0	2,100,000	-	-	480,000	-	-
25, ...	6,300	2,700	1,480,000	18	3.00	1,740,000	-	-
26, ...	3,600	8,000	1,720,000	26	2.30	1,700,000	18	0
27, ...	8,000	3,400	1,300,000	26	3.50	1,560,000	5	0
28, ...	5,300	3,000	1,800,000	48	8.30	1,520,000	12	0
29, ...	9,800	0	1,480,000	25	3.00	1,600,000	6	0
30, ...	5,500	0	1,480,000	25	4.00	1,480,000	15	0
31, ...	-	0	1,600,000	-	-	480,000	-	-

City water was applied instead of river water October 6, 2.30 P.M., to October 7, 8.10 A.M.; October 8, 3.30 P.M., to October 10, 8.30 A.M.

Filters Nos. 18 A and 41—Continued.

Date—1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 18 A.			Filter No. 41.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
November 1,	18,000	0	1,580,000	16	-	1,080,000	30	-
2,	17,000	0	1,860,000	16	-	1,660,000	30	-
3,	13,000	0	1,360,000	51	-	1,280,000	6	-
4,	14,000	0	2,040,000	28	-	1,360,000	20	-
5,	17,000	0	1,380,000	105	-	1,320,000	36	-
6,	27,000	0	1,460,000	174	-	1,440,000	29	-
7,	-	0	2,120,000	-	-	820,000	-	-
8,	16,000	0	1,620,000	87	-	1,080,000	22	-
9,	8,000	0	1,500,000	174	-	1,400,000	29	-
10,	13,000	0	1,540,000	93	-	1,220,000	27	-
11,	23,000	0	960,000	15	-	1,200,000	19	-
12,	22,000	0	1,920,000	52	-	1,180,000	23	-
13,	28,000	0	1,700,000	61	-	1,200,000	-	-
14,	-	0	1,240,000	-	-	340,000	-	-
15,	12,500	0	1,560,000	48	-	1,080,000	15	-
16,	7,200	0	1,280,000	18	-	1,180,000	25	-
17,	4,800	0	1,220,000	17	-	1,240,000	8	-
18,	5,200	0	1,340,000	22	-	1,280,000	7	-
19,	8,600	0	660,000	192	-	1,280,000	9	-
20,	9,800	0	1,560,000	144	-	1,140,000	7	-
21,	-	0	1,520,000	-	-	480,000	-	-
22,	5,000	0	1,720,000	92	-	1,340,000	4	-
23,	3,400	0	1,460,000	70	-	1,140,000	7	-
24,	3,000	0	1,540,000	62	-	1,020,000	6	-
25,	1,500	0	1,440,000	48	-	1,020,000	2	-
26,	4,000	0	1,520,000	20	-	1,060,000	3	-
27,	4,300	0	1,700,000	47	-	820,000	4	-
28,	-	0	1,680,000	-	-	480,000	-	-
29,	2,300	0	1,960,000	27	-	500,000	-	-
30,	2,600	0	1,080,000	110	-	720,000	2	-

City water applied instead of river water November 24, 8 A.M., to November 25, 8 A.M.
The loam was removed from Filter No. 41 on November 30.

Filters Nos. 18 A and 41 — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 18 A.			Filter No. 41.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. — Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. — Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. — Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. — Bacillus Prodigiosus.
December 1,	4,800		1,380,000	43	-	2,280,000	7	-
2,	4,200	0	1,360,000	44	-	2,180,000	474	-
3,	3,200	0	1,100,000	45	-	2,320,000	510	-
4,	2,800	0	1,700,000	27	-	2,000,000	630	-
5,	-	0	1,940,000	-	-	300,000	-	-
6,	6,000	0	1,300,000	27	-	180,000	-	-
7,	4,800	3,500	1,300,000	12	-	2,320,000	900	65
8,	4,500	6,000	1,120,000	12	-	2,420,000	873	59
9,	4,700	5,000	1,220,000	15	-	2,100,000	476	48
10,	11,400	12,000	1,020,000	18	-	1,860,000	615	47
11,	6,700	6,000	1,400,000	20	-	2,140,000	547	85
12,	-	0	1,100,000	-	-	40,000	-	-
13,	4,200	7,000	1,600,000	73	-	2,560,000	356	88
14,	4,100	6,000	1,860,000	55	-	2,400,000	343	82
15,	5,000	6,000	1,080,000	47	-	2,460,000	990	52
16,	4,100	5,000	1,400,000	30	-	2,500,000	414	24
17,	4,500	7,000	1,460,000	25	-	2,660,000	670	80
18,	1,800	6,000	1,620,000	30	-	1,800,000	421	95
19,	-	0	1,740,000	-	-	340,000	-	-
20,	7,800	3,000	1,460,000	36	-	2,460,000	460	112
21,	10,300	6,000	1,400,000	35	-	2,480,000	1,352	32
22,	6,600	3,000	1,500,000	94	-	2,160,000	610	40
23,	6,300	4,000	1,400,000	54	-	2,440,000	690	27
24,	8,500	6,000	1,120,000	74	-	2,620,000	960	32
25,	0	0	0	-	-	0	-	-
26,	0	0	0	-	-	0	-	-
27,	0	0	0	-	-	0	-	-
28,	14,500	0	560,000	448	-	1,800,000	-	-
29,	11,000	1,000	880,000	558	-	2,480,000	1,355	8
30,	18,000	3,000	900,000	1,008	-	2,660,000	1,240	15
31,	11,700	3,000	1,280,000	684	-	2,960,000	1,875	27

On December 25-27 the water pipes were frozen. Channels were also formed at sides of filters (see page 477). From December 7-31 B. prodigiosus was applied to Filter No. 41 but not to No. 18 A.

Filters Nos. 33 A and 34 A.

[These filters were both operated continuously.]

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 33 A.			Filter No. 34 A.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
June 1, . . .	500	2,100,000	-	-	2,020,000	-	-
2, . . .	6,500	2,060,000	-	-	2,020,000	-	-
3, . . .	1,800	1,980,000	-	-	1,960,000	-	-
4, . . .	2,100	2,000,000	-	-	2,040,000	-	-
5, . . .	2,700	1,900,000	-	-	1,900,000	-	-
6, . . .	-	1,760,000	-	-	1,740,000	-	-
7, . . .	1,100	1,940,000	-	21	1,960,000	-	19
8, . . .	5,200	1,940,000	-	17	2,060,000	-	8
9, . . .	4,500	2,020,000	-	15	1,880,000	-	8
10, . . .	4,400	1,940,000	-	2	1,540,000	-	7
11, . . .	4,000	2,000,000	8.5	0	1,780,000	-	2
12, . . .	3,500	1,760,000	-	5	1,760,000	-	2
13, . . .	-	60,000	6.5	-	60,000	21.0	-
14, . . .	1,300	2,020,000	10.0	18	2,020,000	34.0	11
15, . . .	12,600	1,960,000	7.5	7	1,900,000	36.0	9
16, . . .	2,600	2,020,000	9.5	8	2,020,000	39.0	7
17, . . .	18,000	1,940,000	10.5	23	1,840,000	45.0	14
18, . . .	14,500	2,000,000	12.0	35	1,880,000	57.0	13
19, . . .	17,100	2,000,000	-	14	1,880,000	-	8
20, . . .	-	2,000,000	14.5	-	1,940,000	65.0	-
21, . . .	1,100	2,040,000	14.0	15	2,060,000	15.5	10
22, . . .	11,700	1,960,000	15.5	18	2,120,000	18.5	14
23, . . .	3,700	2,060,000	17.5	5	2,020,000	25.5	7
24, . . .	2,700	2,000,000	19.5	5	2,040,000	32.0	5
25, . . .	2,700	2,080,000	22.0	9	1,900,000	43.0	10
26, . . .	2,600	2,120,000	-	15	2,100,000	-	11
27, . . .	-	1,820,000	26.0	-	1,920,000	52.0	-
28, . . .	2,700	2,080,000	28.0	9	1,860,000	58.0	12
29, . . .	9,200	2,000,000	29.0	13	2,140,000	14.0	26
30, . . .	1,300	2,000,000	32.0	4	2,100,000	21.0	2

Filters Nos. 33 A and 34 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 33 A.			Filter No. 34 A.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
July 1, . . .	500	2,020,000	36.0	4	1,980,000	34.0	11
2, . . .	1,300	2,120,000	35.0	2	1,800,000	47.0	4
3, . . .	3,900	1,800,000	-	22	1,800,000	-	30
4, . . .	-	0	-	-	0	-	-
5, . . .	-	0	-	-	0	-	-
6, . . .	2,500	2,000,000	49.0	138	1,900,000	54.0	12
7, . . .	1,300	1,920,000	57.0	9	1,880,000	58.0	11
8, . . .	800	2,120,000	6.0	17	2,040,000	12.0	11
9, . . .	1,600	2,000,000	6.0	22	1,940,000	13.0	12
10, . . .	3,000	2,020,000	-	39	2,080,000	-	2
11, . . .	-	1,980,000	4.5	-	2,120,000	11.0	-
12, . . .	800	2,000,000	5.0	4	2,020,000	14.0	10
13, . . .	6,100	2,000,000	7.0	2	2,120,000	17.0	3
14, . . .	9,300	2,040,000	8.0	25	2,020,000	20.0	31
15, . . .	21,900	2,020,000	11.0	11	1,980,000	26.0	8
16, . . .	8,200	2,020,000	14.0	22	2,080,000	31.0	29
17, . . .	6,000	2,100,000	-	25	2,000,000	-	13
18, . . .	-	2,040,000	13.0	-	2,020,000	32.0	-
19, . . .	500	2,040,000	21.0	12	2,020,000	46.0	13
20, . . .	1,000	2,000,000	25.0	6	2,020,000	54.0	15
21, . . .	4,700	2,040,000	28.0	7	1,860,000	63.0	2
22, . . .	16,900	1,940,000	33.0	26	1,880,000	65.0	37
23, . . .	6,500	1,980,000	35.0	3	1,860,000	+	4
24, . . .	5,500	2,020,000	-	8	2,020,000	-	14
25, . . .	-	1,820,000	43.0	-	1,960,000	16.0	-
26, . . .	1,300	1,980,000	54.0	22	1,940,000	19.0	163
27, . . .	1,100	2,000,000	57.0	118	2,020,000	25.0	1,680†
28, . . .	2,200	2,020,000	+*	212	2,000,000	35.0	594
29, . . .	3,500	1,940,000	+	254	2,040,000	44.0	726
30, . . .	1,000	2,040,000	+	186	2,000,000	56.0	84
31, . . .	1,200	1,840,000	-	714	1,840,000	-	85

* The sign + is given when no water stood in the glass tube attached to the filter at the bottom.

† Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water July 9, 12 M., to July 11, 9 A.M.; July 16, 2 P.M., to July 18, 10 A.M.; July 30, 2.15 P.M., to August 1, 8.00 A.M.

Filters Nos. 33 A and 34 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 33 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.	Filter No. 34 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.
August 1, . .	-	2,000,000	5.0	-	2,000,000	12.0	-
2, . .	500	1,980,000	8.0	2,222*	2,020,000	16.0	756
3, . .	650	1,980,000	14.0	7,344	2,000,000	27.0	840
4, . .	12,000	2,120,000	17.0	-	2,080,000	32.0	54
5, . .	-	2,020,000	23.0	86	2,000,000	43.0	46
6, . .	6,000	1,960,000	33.0	16	1,840,000	53.0	57
7, . .	2,000	2,120,000	-	16	2,000,000	-	450
8, . .	-	2,140,000	31.0	-	2,400,000	48.0	-
9, . .	1,600	1,960,000	49.0	950	1,780,000	+	27.
10, . .	2,200	1,960,000	58.0	1,700	1,580,000	+	700
11, . .	5,600	1,060,000	5.0	90	1,760,000	16.0	222
12, . .	1,900	1,960,000	6.0	20	2,060,000	25.0	7
13, . .	2,000	2,080,000	8.0	63	2,160,000	35.0	240
14, . .	2,800	2,020,000	8.0	45	2,060,000	37.0	70
15, . .	-	2,000,000	8.0	-	2,080,000	38.0	-
16, . .	1,000	1,960,000	13.0	31	1,920,000	58.0	7
17, . .	3,000	2,020,000	-	3	1,980,000	+	-
18, . .	6,700	1,980,000	21.0	58	1,920,000	12.0	22
19, . .	1,200	2,020,000	25.0	26	2,020,000	16.0	30
20, . .	15,600	1,960,000	30.0	68	2,060,000	21.0	300
21, . .	7,100	2,080,000	-	46	2,180,000	-	19
22, . .	-	2,080,000	26.0	-	2,340,000	23.0	-
23, . .	2,400	1,920,000	34.0	19	1,980,000	38.0	11
24, . .	10,500	2,000,000	42.0	28	1,960,000	55.0	8
25, . .	8,000	1,980,000	49.0	75	1,900,000	+	41
26, . .	5,900	2,000,000	53.0	37	1,540,000	+	30
27, . .	7,600	1,980,000	57.0	40	1,920,000	13.0	55
28, . .	-	2,040,000	-	-	2,100,000	-	-
29, . .	-	2,060,000	56.0	46	2,040,000	12.0	55
30, . .	11,400	1,840,000	+	35	2,020,000	22.0	19
31, . .	3,100	1,780,000	+	74	1,980,000	34.0	45

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water August 6, 2 P.M., to August 8, 8 A.M.; August 13, 2.15 P.M., to August 15, 9 A.M.; August 20, 2 P.M., to August 22, 9.30 A.M.; August 27, 2 P.M., to August 29, 9.30 A.M.

Filters No. 33 A and 34 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 33 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.	Filter No. 34 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.
September 1, . .	1,500	1,940,000	6.0	41	2,060,000	41.0	24
2, . .	1,700	2,000,000	7.0	26	2,060,000	43.0	32
3, . .	2,900	2,040,000	8.0	37	2,000,000	51.0	36
4, . .	8,800	2,040,000	-	14	2,000,000	-	13
5, . .	-	2,040,000	10.0	-	1,960,000	61.0	-
6, . .	-	2,040,000	10.0	-	2,000,000	64.0	-
7, . .	1,800	1,960,000	18.0	16	1,880,000	+	26
8, . .	16,200	2,000,000	25.0	14	1,400,000	+	10
9, . .	18,700	2,000,000	32.0	25	2,100,000	17.0	17
10, . .	7,900	2,020,000	38.0	37	2,060,000	26.0	14
11, . .	12,800	1,980,000	-	45	2,000,000	-	10
12, . .	-	1,920,000	49.0	-	1,960,000	41.0	-
13, . .	6,000	2,000,000	52.0	24	2,040,000	44.0	10
14, . .	7,500	2,040,000	57.0	18	2,040,000	48.0	10
15, . .	10,800	2,040,000	57.0	14	1,140,000	57.0	7

City water was applied instead of river water September 3, 2.30 P.M., to September 6, 8 A.M.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water. Water Bacteria.	Bacillus Prodigiosus.	Filter No. 33 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacillus Prodigiosus.	Filter No. 34 A. Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacillus Prodigiosus.
September 16, .	-	0	2,020,000	+	-	-	1,980,000	+	-	-
17, .	18,200	1,000	1,880,000	+	23	0.00	1,860,000	+	42	0.00
18, .	4,400	350	2,000,000	+	22	0.00	1,400,000	+	36	0.00
19, .	-	0	1,060,000	+	-	-	1,060,000	+	-	-
20, .	1,400	2,000	1,980,000	9	22	2.50	2,000,000	16	30	0.25
21, .	6,600	7,500	2,060,000	9	16	3.75	1,960,000	23	18	0.25
22, .	23,000	7,500	2,020,000	10	33	2.75	1,960,000	33	39	0.50
23, .	23,000	6,800	1,980,000	13	30	1.50	1,940,000	46	35	5.25
24, .	5,200	8,300	2,120,000	13	27	0.00	2,000,000	57	38	1.00
25, .	19,000	6,500	2,100,000	-	42	1.25	2,100,000	-	29	1.50
26, .	-	0	2,080,000	12	-	-	2,040,000	54	-	-
27, .	6,000	3,000	2,020,000	18	12	2.00	1,900,000	+	11	0.20
28, .	8,000	4,000	2,000,000	25	72	2.75	1,700,000	+	24	0.00
29, .	46,000	5,300	2,020,000	33	484	2.00	1,800,000	24	20	0.75
30, .	44,000	2,200	2,000,000	42	132	0.75	1,900,000	44	49	0.50

City water was applied instead of river water September 25, 8 45 A.M., to September 26, 9 A.M.

Filters Nos. 33 A and 34 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 33 A.				Filter No. 34 A.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
October 1,	44,000	2,500	2,040,000	46	66	1.75	1,840,000	61	55	1.00
2,	28,000	2,700	2,120,000	-	98	1.25	1,840,000	-	62	0.75
3,	-	-	2,060,000	53	-	-	1,360,000	+	-	-
4,	18,000	3,700	1,980,000	+	42	1.25	1,960,000	16	53	0
5,	14,000	3,200	2,080,000	+	70	1.75	2,000,000	19	30	0.50
6,	23,000	4,600	1,940,000	+	32	3.50	1,960,000	25	34	0
7,	1,300	4,000	1,920,000	+	68	0.75	2,040,000	29	30	0.50
8,	19,600	0	1,860,000	7	68	0	2,020,000	31	30	0
9,	14,000	0	2,020,000	-	155	0	2,040,000	-	29	0
10,	-	0	1,980,000	8	-	-	2,040,000	26	-	-
11,	10,000	0	2,020,000	11	138	0	2,040,000	29	22	0
12,	11,000	0	2,000,000	13	46	0	1,940,000	35	11	0
13,	10,000	0	2,020,000	15	18	0	2,080,000	37	13	0
14,	11,000	0	2,080,000	18	35	0	2,040,000	40	18	0
15,	21,000	0	2,060,000	20	31	1.00	1,980,000	48	19	0
16,	18,000	0	2,000,000	-	18	0	1,940,000	-	27	0
17,	-	0	1,860,000	29	-	-	1,780,000	60	-	-
18,	15,000	0	2,200,000	37	23	0	2,000,000	61	18	0
19,	4,100	0	2,100,000	26	43	1.00	1,420,000	63	15	0
20,	10,000	0	2,060,000	30	184	0	1,980,000	+	16	0
21,	4,200	0	2,040,000	35	26	0	1,740,000	+	15	0
22,	5,000	0	1,980,000	42	8	0	1,860,000	18	17	0
23,	16,000	0	2,000,000	-	43	0	2,080,000	-	150	0
24,	-	0	1,920,000	51	-	-	2,040,000	19	-	-
25,	6,300	0	1,980,000	58	18	0	2,040,000	21	7	0
26,	3,600	0	2,040,000	+	9	0	1,980,000	23	17	0
27,	8,000	0	1,980,000	+	14	1.00	2,060,000	25	12	0
28,	5,300	0	1,980,000	+	22	0	1,940,000	31	12	0
29,	9,800	0	1,700,000	+	22	0	2,060,000	34	29	0
30,	5,500	0	2,000,000	-	16	0	2,040,000	-	20	0
31,	-	0	2,000,000	7	-	-	2,000,000	38	-	-

City water was applied instead of river water October 6, 2.30 P.M., to October 7, 8.10 A.M.; October 8, 3.30 P.M., to October 10, 8.30 A.M.

Filters Nos. 33 A and 34 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 33 A.				Filter No. 34 A.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
November 1, .	18,000	17,000	2,120,000	8	61	-	1,000,000	29	12	0.70
2, .	17,000	13,000	2,080,000	9	125	-	1,020,000	33	21	0.0
3, .	13,000	3,000	2,060,000	10	98	-	980,000	36	24	0.0
4, .	10,000	16,000	2,000,000	12	96	-	960,000	43	15	1.0
5, .	12,000	16,000	2,040,000	14	37	-	1,020,000	45	20	0.3
6, .	27,000	13,500	2,060,000	-	27	-	1,040,000	-	22	1.0
7, .	-	0	2,000,000	18	-	-	1,020,000	57	-	-
8, .	16,000	9,000	2,040,000	20	42	-	1,040,000	57	28	2.0
9, .	8,000	12,000	2,040,000	23	45	-	960,000	+	14	0.8
10, .	13,000	16,000	1,980,000	25	34	-	1,060,000	+	29	0.5
11, .	23,000	14,000	2,000,000	28	19	-	900,000	+	26	1.0
12, .	22,000	17,000	2,060,000	32	12	-	1,000,000	12	66	0.3
13, .	28,000	10,000	2,040,000	-	74	-	1,020,000	-	18	0.5
14, .	-	0	2,000,000	36	-	-	1,100,000	12	-	-
15, .	12,500	18,000	1,960,000	40	70	-	1,020,000	13	30	0.0
16, .	7,200	10,000	480,000	19	80	-	480,000	7	29	0.0
17, .	4,800	2,300	520,000	21	275	0.0	480,000	8	26	0.0
18, .	5,200	17,000	500,000	24	76	0.0	520,000	10	25	0.0
19, .	8,600	10,000	500,000	29	176	0.0	500,000	13	16	0.0
20, .	9,800	6,000	520,000	-	174	0.5	520,000	-	15	0.0
21, .	-	0	500,000	34	-	-	520,000	13	-	-
22, .	5,000	5,000	520,000	35	23	0.0	520,000	15	9	0.0
23, .	3,400	4,000	500,000	37	22	0.0	500,000	18	13	0.0
24, .	3,000	10,000	500,000	43	90	0.8	520,000	19	20	0.0
25, .	1,500	3,000	540,000	38	45	0.0	500,000	16	13	0.0
26, .	4,000	9,000	500,000	45	25	0.0	500,000	22	6	0.0
27, .	4,300	12,000	500,000	-	29	0.0	500,000	-	6	0.5
28, .	-	0	500,000	48	-	-	520,000	24	-	-
29, .	2,300	10,000	520,000	50	38	0.0	520,000	27	7	0.5
30, .	2,600	13,000	520,000	51	48	0.0	500,000	29	6	0.0

City water was applied instead of river water November 24, 8 A.M., to November 25, 8 A.M.

Filters Nos. 33 A and 34 A — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 33 A.				Filter No. 34 A.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
December 1, .	4,800	11,000	500,000	53	52	0	500,000	34	11	0.3
2, .	4,200	3,000	500,000	55	33	0.5	540,000	36	6	1
3, .	3,200	9,000	520,000	56	26	1.0	480,000	41	11	0
4, .	2,800	9,000	500,000	-	41	0	520,000	-	13	0
5, .	-	0	480,000	+	-	-	520,000	47	-	-
6, .	6,000	2,000	520,000	+	34	0.3	500,000	48	15	0
7, .	4,800	3,500	540,000	+	30	0.5	500,000	52	9	0
8, .	4,500	6,000	540,000	+	30	0	520,000	55	14	0
9, .	4,700	5,000	520,000	+	42	0	500,000	56	15	0
10, .	11,400	12,000	520,000	+	39	0	500,000	59	12	0.3
11, .	6,700	6,000	500,000	+	39	0	500,000	-	12	0
12, .	-	0	460,000	+	-	-	460,000	61	-	-
13, .	4,200	7,000	2,800,000	22	65	17	2,820,000	37	156	6
14, .	4,100	6,000	2,980,000	25	154	80	3,100,000	39	161	56
15, .	5,000	6,000	3,020,000	29	463	40	3,100,000	43	403	40
16, .	4,100	5,000	2,980,000	34	486	58	3,060,000	48	532	52
17, .	4,500	7,000	3,000,000	38	496	22	2,960,000	55	823	20
18, .	1,800	6,000	3,000,000	-	403	84	3,000,000	-	1,092	78
19, .	-	0	2,860,000	52	-	-	2,800,000	+	-	-
20, .	7,800	3,000	2,900,000	+	307	31	2,540,000	+	834	38
21, .	10,300	6,000	3,100,000	+	101	9	2,520,000	44	394	57
22, .	6,600	3,000	2,740,000	+	172	13	3,020,000	51	450	20
23, .	6,300	4,000	3,020,000	30	177	13	2,820,000	64	483	7
24, .	8,500	6,000	2,800,000	-	189	7	2,700,000	-	577	7
25, .	-	0	600,000	-	-	-	600,000	-	-	-
26, .	-	-	0	-	-	-	0	-	-	-
27, .	-	-	0	-	-	-	0	-	-	-
28, .	14,000	0	2,000,000	+	132	5	1,620,000	+	258	12
29, .	11,000	1,000	1,480,000	+	145	5.8	2,000,000	+	727	2
30, .	18,000	3,000	2,260,000	+	188	12	1,720,000	+	1,053	6.3
31, .	11,700	3,000	2,420,000	+	259	4.3	2,280,000	+	532	3.5

Water pipes were frozen December 25-27. Channels at sides of filters were formed (see page 477).

Filters Nos. 35 A and 36 A.

[The construction of these two filters was the same; No. 35 A was operated intermittently and No. 36 A continuously.]

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 35 A.		Filter No. 36 A.	
		Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.
June 1,	500	1,900,000	-	1,520,000	-
2,	6,500	1,920,000	-	1,520,000	-
3,	1,800	1,440,000	-	1,540,000	-
4,	2,100	1,480,000	-	1,580,000	-
5,	2,700	1,940,000	-	1,560,000	-
6,	-	280,000	-	1,580,000	-
7,	1,100	1,620,000	-	1,580,000	8
8,	5,200	1,740,000	7	1,580,000	31
9,	4,500	1,500,000	19	1,600,000	2
10,	4,400	1,540,000	16	1,580,000	12
11,	4,000	1,720,000	1	1,540,000	546
12,	3,500	1,100,000	2	1,300,000	1
13,	-	40,000	-	0	-
14,	1,300	1,400,000	-	1,540,000	5
15,	12,600	580,000	14	1,500,000	4
16,	2,600	1,600,000	2	1,480,000	13
17,	18,000	1,600,000	44	1,520,000	26
18,	14,500	1,320,000	27	1,560,000	13
19,	17,100	1,540,000	18	1,500,000	10
20,	-	380,000	-	1,480,000	-
21,	1,100	360,000	-	1,480,000	18
22,	11,700	1,820,000	2	1,540,000	22
23,	3,700	1,620,000	9	1,500,000	14
24,	2,700	1,660,000	7	1,500,000	18
25,	2,700	1,740,000	14	1,500,000	12
26,	2,600	1,300,000	12	1,520,000	12
27,	-	360,000	-	1,560,000	-
28,	2,700	1,040,000	-	1,440,000	10
29,	9,200	1,180,000	5	1,540,000	6
30,	1,300	620,000	4	1,540,000	5

Filters Nos. 35 A and 36 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 35 A.		Filter No. 36 A.	
		Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent.
July 1,	500	620,000	42	1,440,000	5
2,	1,300	540,000	9	1,440,000	5
3,	3,900	740,000	46	1,520,000	17
4,	-	300,000	-	1,520,000	-
5,	-	0	-	1,520,000	-
6,	2,500	160,000	-	1,480,000	3
7,	1,300	320,000	6	1,320,000	7
8,	800	1,580,000	2	1,500,000	11
9,	1,600	1,640,000	8	1,520,000	1
10,	3,000	100,000	14	1,520,000	4
11,	-	20,000	-	1,500,000	-
12,	800	1,320,000	-	1,500,000	9
13,	6,100	1,540,000	3	1,540,000	5
14,	9,300	1,500,000	66	1,540,000	10
15,	21,900	1,200,000	22	1,500,000	5
16,	8,200	1,360,000	6	1,520,000	8
17,	6,000	100,000	23	1,520,000	5
18,	-	0	-	1,520,000	-
19,	500	1,540,000	-	1,500,000	8
20,	1,000	1,580,000	15	1,580,000	14
21,	4,700	1,580,000	32	1,560,000	13
22,	16,900	1,580,000	46	1,520,000	66
23,	6,500	1,540,000	41	1,500,000	7
24,	5,500	1,540,000	32	1,500,000	34
25,	-	240,000	-	1,480,000	-
26,	1,300	1,380,000	-	1,480,000	238
27,	1,100	1,720,000	21	1,520,000	12,544*
28,	2,200	1,620,000	38	1,580,000	234
29,	3,500	1,620,000	22	1,520,000	222
30,	1,000	1,660,000	22	1,500,000	336
31,	1,200	240,000	12	1,560,000	798

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water July 9, 12 M., to July 11, 9 A.M.; July 16, 2 P.M., to July 18, 10 A.M.; July 30, 2.15 P.M., to August 1, 8.50 A.M.

Filters Nos. 35 A and 36 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 35 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 35 A. Bacteria per Cubic Centimeter in Effluent.	Filter No. 36 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 36 A. Bacteria per Cubic Centimeter in Effluent.
August 1,	-	60,000	-	1,560,000	-
2,	500	1,520,000	-	1,500,000	2,379*
3,	650	1,320,000	10	1,580,000	948
4,	12,000	1,200,000	11	1,500,000	253
5,	8,000	960,000	6,560	1,460,000	25
6,	6,000	1,700,000	9	1,500,000	70
7,	2,000	140,000	1,400	1,560,000	20
8,	-	40,000	-	1,680,000	-
9,	1,600	780,000	-	1,440,000	91
10,	2,200	1,580,000	25	1,480,000	68
11,	5,600	1,600,000	36	1,500,000	36
12,	1,900	1,680,000	38	1,520,000	15
13,	2,000	820,000	53	1,460,000	342
14,	2,800	240,000	9	1,640,000	130
15,	-	20,000	-	1,720,000	-
16,	1,000	1,060,000	-	1,360,000	115
17,	3,000	1,600,000	5	1,400,000	29
18,	6,700	1,640,000	26	1,600,000	98
19,	1,200	1,680,000	72	1,520,000	95
20,	15,600	1,620,000	110	1,500,000	120
21,	7,100	200,000	Liq.	1,500,000	34
22,	-	20,000	-	1,300,000	-
23,	2,400	1,420,000	-	1,420,000	86
24,	10,500	1,580,000	30	1,520,000	32
25,	8,000	1,740,000	79	1,560,000	40
26,	5,900	1,600,000	44	1,500,000	50
27,	7,600	1,080,000	52	1,480,000	56
28,	-	440,000	31	1,520,000	-
29,	-	20,000	-	1,540,000	66
30,	11,400	160,000	-	1,500,000	54
31,	3,100	360,000	22	1,540,000	163

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water August 6, 2 P.M., to August 8, 8 A.M.; August 13, 2.15 P.M., to August 15, 9 A.M.; August 20, 2 P.M., to August 22, 9.30 A.M.; August 27, 2 P.M., to August 29, 9.30 A.M.

Filters Nos. 35 A and 36 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 35 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 35 A. Bacteria per Cubic Centimeter in Effluent.	Filter No. 36 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 36 A. Bacteria per Cubic Centimeter in Effluent.
September 1,	1,500	1,480,000	29	1,500,000	104
2,	1,700	1,640,000	30	1,500,000	11
3,	2,900	1,640,000	100	1,500,000	18
4,	8,800	100,000	110	1,600,000	17
5,	–	20,000	–	1,620,000	–
6,	–	0	–	1,520,000	–
7,	1,800	1,440,000	–	1,500,000	25
8,	16,200	2,080,000	29	1,580,000	20
9,	18,700	2,140,000	300	1,560,000	30
10,	7,900	2,000,000	190	1,500,000	18
11,	12,800	1,580,000	95	1,520,000	9
12,	–	400,000	–	1,480,000	–
13,	6,000	1,980,000	–	1,480,000	5
14,	7,500	1,100,000	53	1,540,000	6
15,	10,800	2,060,000	10	1,480,000	17

City water was applied instead of river water September 3, 2.30 P.M., to September 6, 8 A.M.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water. Water Bacteria.	Bacteria per Cubic Centimeter in Applied Water. Bacillus Prodigiosus.	Filter No. 35 A. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 35 A. Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Filter No. 35 A. Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Filter Tank No. 36 A. Rate of Filtration. — Gallons per Acre Daily.	Filter Tank No. 36 A. Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Filter Tank No. 36 A. Bacteria per Cubic Centimeter in Effluent. Bacillus Prodiglosus.
September 16,	–	0	340,000	–	–	1,560,000	–	–
17,	18,200	1,000	1,180,000	18	0.00	1,460,000	22	0.50
18,	4,400	350	780,000	18	0.00	1,400,000	15	0.00
19,	–	0	80,000	–	–	800,000	–	–
20,	1,400	2,000	1,780,000	93	1.00	1,500,000	35	1.50
21,	6,600	7,500	1,280,000	16	7.00	1,540,000	30	8.00
22,	23,000	7,500	1,340,000	45	4.00	1,520,000	32	6.00
23,	23,000	6,800	1,940,000	57	13.00	1,520,000	30	3.75
24,	5,200	8,300	1,700,000	50	5.00	1,520,000	57	1.00
25,	19,000	6,500	1,620,000	104	1.25	1,520,000	33	0.50
26,	–	0	40,000	–	–	1,520,000	–	–
27,	6,000	3,000	1,500,000	43	1.20	1,520,000	19	0.20
28,	8,000	4,000	1,420,000	21	2.00	1,500,000	22	1.75
29,	46,000	5,300	2,260,000	277	5.00	1,560,000	349	3.00
30,	44,000	2,200	1,860,000	466	2.00	1,500,000	220	2.00

City water was applied instead of river water September 25, 8.45 A.M., to September 26, 8.10 A.M.

Filters Nos. 35 A and 36 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 35 A.			Filter Tank No. 36 A.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
October 1, . . .	44,000	2,500	1,940,000	238	3.50	1,520,000	139	1.00
2, . . .	28,000	2,700	1,980,000	157	1.25	1,520,000	65	1.00
3, . . .	-	-	40,000	-	-	1,480,000	-	-
4, . . .	18,000	3,700	2,060,000	112	3.75	1,580,000	60	0.30
5, . . .	14,000	3,200	1,360,000	75	0.25	1,520,000	44	1.00
6, . . .	23,000	4,600	1,380,000	48	2.50	1,500,000	63	1.25
7, . . .	1,300	4,000	1,040,000	43	0.50	1,580,000	97	0.75
8, . . .	19,600	0	1,200,000	51	0.00	1,580,000	97	0
9, . . .	14,000	0	2,380,000	180	5.00	1,600,000	117	0
10, . . .	-	0	20,000	-	-	1,700,000	-	-
11, . . .	10,000	0	1,920,000	-	-	1,520,000	63	0
12, . . .	11,000	0	2,100,000	126	1.00	1,500,000	44	0
13, . . .	10,000	0	2,140,000	86	0	1,560,000	11	0
14, . . .	11,000	0	1,920,000	99	0	1,520,000	43	0
15, . . .	21,000	0	2,220,000	40	0	1,500,000	37	0
16, . . .	18,000	0	2,100,000	34	0	1,500,000	23	6
17, . . .	-	0	400,000	-	-	1,480,000	-	-
18, . . .	15,000	0	1,860,000	-	-	1,680,000	16	0
19, . . .	4,100	0	1,880,000	20	0	1,480,000	10	0
20, . . .	10,000	0	2,540,000	57	0	1,560,000	22	0
21, . . .	4,200	0	2,700,000	14	0	1,560,000	14	0
22, . . .	5,000	0	2,560,000	23	0	1,500,000	7	0
23, . . .	16,000	0	1,800,000	51	0	1,560,000	25	0
24, . . .	-	0	460,000	-	-	1,520,000	-	-
25, . . .	6,300	0	1,880,000	-	-	1,500,000	16	0
26, . . .	3,600	0	1,860,000	21	0	1,520,000	12	0
27, . . .	8,000	0	2,180,000	9	0	1,520,000	22	0
28, . . .	5,300	0	1,900,000	18	0	1,480,000	25	0
29, . . .	9,800	0	1,900,000	39	0	1,520,000	21	0
30, . . .	5,500	0	1,640,000	16	0	1,540,000	38	0
31, . . .	-	0	460,000	-	-	1,520,000	-	-

City water was applied instead of river water October 6, 2.30 P.M., to October 7, 8.00 A.M.; October 8, 3.30 P.M., to October 10, 8.30 A.M.

Filters Nos. 35 A and 36 A — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 35 A.			Filter Tank No. 36 A.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
November 1, . . .	18,000	17,000	1,280,000	67	0.0	2,980,000	29	1.40
2, . . .	17,000	13,000	1,380,000	19	3.5	3,000,000	20	19.5
3, . . .	13,000	3,000	1,180,000	12	3.3	3,000,000	81	7.3
4, . . .	10,000	16,000	1,440,000	15	2.3	3,020,000	47	5.8
5, . . .	12,000	16,000	1,360,000	15	3.8	2,980,000	76	3.8
6, . . .	27,000	13,500	1,300,000	59	2.3	3,000,000	142	2.8
7, . . .	-	0	100,000	-	-	2,860,000	-	-
8, . . .	16,000	9,000	1,640,000	30	8.3	3,000,000	65	3.8
9, . . .	8,000	12,000	1,120,000	44	1.8	2,960,000	94	1.0
10, . . .	13,000	16,000	1,180,000	33	4.3	2,920,000	54	10.0
11, . . .	23,000	14,000	1,140,000	17	2.3	2,480,000	74	11.0
12, . . .	22,000	17,000	780,000	32	2.0	2,960,000	94	14.3
13, . . .	28,000	10,000	780,000	48	10.0	3,120,000	97	4.0
14, . . .	-	0	80,000	-	-	3,120,000	-	-
15, . . .	12,500	18,000	840,000	87	7.3	3,100,000	91	3.8
16, . . .	7,200	10,000	800,000	56	2.0	3,000,000	20	1.8
17, . . .	4,800	2,300	1,280,000	-	-	3,100,000	50	1.8
18, . . .	5,200	17,000	1,220,000	39	-	2,900,000	28	0.0
19, . . .	8,600	10,000	420,000	204	-	2,820,000	20	1.8
20, . . .	9,800	6,000	1,360,000	41	-	2,800,000	52	11.3
21, . . .	-	0	0	-	-	2,000,000	-	-
22, . . .	5,000	5,000	1,420,000	42	-	3,200,000	47	5.0
23, . . .	3,400	4,000	1,160,000	16	-	3,040,000	20	2.0
24, . . .	3,000	10,000	1,120,000	32	-	3,040,000	24	2.5
25, . . .	1,500	3,000	1,240,000	24	-	3,100,000	21	5.0
26, . . .	4,000	9,000	1,180,000	13	-	3,000,000	18	3.0
27, . . .	4,300	12,000	1,080,000	7	-	3,040,000	29	4.3
28, . . .	-	0	60,000	-	-	2,980,000	-	-
29, . . .	2,300	10,000	1,220,000	12	-	3,000,000	6	1.0
30, . . .	2,600	13,000	940,000	7	-	3,020,000	26	3.3

City water was applied instead of river water November 24, 8 A.M., to November 25, 8 A.M. From November 17 to 30 B. prodigiosus was applied to Filter No. 36 A but not to No. 35 A.

Filters Nos. 35 A and 36 A — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 35 A.			Filter Tank No. 36 A.		
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
December 1,	4,800	11,000	920,000	19	-	2,980,000	18	7.3
2,	4,200	3,000	980,000	23	-	2,960,000	18	5.5
3,	3,200	9,000	960,000	12	-	2,880,000	18	5.0
4,	2,800	9,000	940,000	23	-	3,000,000	21	5.8
5,	-	0	80,000	-	-	2,280,000	-	-
6,	6,000	2,000	1,240,000	39	-	3,000,000	37	9.0
7,	4,800	3,500	880,000	39	-	3,020,000	25	4.3
8,	4,500	6,000	800,000	24	-	3,000,000	15	1.0
9,	4,700	5,000	760,000	24	-	2,960,000	14	1.3
10,	11,400	12,000	1,200,000	33	-	3,020,000	17	0.8
11,	6,700	6,000	1,140,000	30	-	3,000,000	16	1.8
12,	-	0	60,000	-	-	2,780,000	-	-
13,	4,200	7,000	1,320,000	41	-	2,040,000	15	0.0
14,	4,100	6,000	1,040,000	29	-	1,740,000	22	0.0
15,	5,000	6,000	1,020,000	20	-	1,980,000	11	0.5
16,	4,100	5,000	1,220,000	14	-	2,220,000	9	1.0
17,	4,500	7,000	960,000	10	-	2,020,000	7	0.5
18,	1,800	6,000	1,020,000	19	-	1,860,000	12	0.3
19,	-	0	0	-	-	1,520,000	-	-
20,	7,800	3,000	1,340,000	32	-	1,820,000	22	0.5
21,	10,300	6,000	940,000	25	-	1,960,000	12	0.3
22,	6,600	3,000	940,000	37	-	2,020,000	14	1.5
23,	6,300	4,000	840,000	19	-	1,740,000	15	2.0
24,	8,500	6,000	700,000	24	-	1,600,000	51	1.5
25,	-	0	0	-	-	0	-	-
26,	-	0	0	-	-	0	-	-
27,	-	0	0	-	-	0	-	-
28,	14,000	0	2,820,000	210	-	640,000	20	0.0
29,	11,000	1,000	1,160,000	2,886	-	1,780,000	399	4.0
30,	18,000	3,000	880,000	780	-	1,740,000	424	22.0
31,	11,700	3,000	1,500,000	648	-	1,900,000	270	18.0

Water pipes were frozen December 25 to 27. Channels were formed at the sides of the filters (see page 477).

B. prodigiosus was not applied to Filter No. 35 A during December.

Filters Nos. 37 and 38.

[These filters, of the same material, were operated continuously; No. 37 is five feet and No. 38 two feet deep.]

Date—1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 37.			Filter No. 38.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
June 1, . . .	500	1,520,000	-	-	1,520,000	-	-
2, . . .	6,500	1,520,000	-	-	1,500,000	-	-
3, . . .	1,800	1,500,000	-	-	1,520,000	-	-
4, . . .	2,100	1,520,000	-	-	1,600,000	-	-
5, . . .	2,700	1,520,000	-	-	1,560,000	-	-
6, . . .	-	1,440,000	-	-	1,460,000	-	-
7, . . .	1,100	1,600,000	-	19	1,500,000	-	54
8, . . .	5,200	1,580,000	-	23	1,460,000	-	77
9, . . .	4,500	1,540,000	-	10	1,520,000	-	11
10, . . .	4,400	1,500,000	-	564	1,480,000	-	14
11, . . .	4,000	1,560,000	-	0	1,580,000	-	7
12, . . .	3,500	1,300,000	-	4	1,300,000	-	9
13, . . .	-	0	6.0	-	0	1.0	-
14, . . .	1,300	1,540,000	8.0	8	1,520,000	3.5	53
15, . . .	12,600	1,560,000	8.0	9	1,500,000	1.5	66
16, . . .	2,600	1,540,000	8.5	8	1,460,000	3.5	23
17, . . .	18,000	1,500,000	11.5	17	1,500,000	5.5	29
18, . . .	14,500	1,460,000	14.5	36	1,460,000	7.0	93
19, . . .	17,100	1,520,000	-	91	1,520,000	-	35
20, . . .	-	1,300,000	16.5	-	1,440,000	10.0	-
21, . . .	1,100	1,600,000	9.0	6	1,520,000	7.5	37
22, . . .	11,700	1,480,000	-	11	1,440,000	7.5	71
23, . . .	3,700	1,500,000	15.0	5	1,480,000	9.0	33
24, . . .	2,700	1,480,000	17.0	7	1,460,000	10.0	84
25, . . .	2,700	1,500,000	20.0	5	1,500,000	12.0	54
26, . . .	2,600	1,500,000	-	5	1,560,000	-	51
27, . . .	-	1,480,000	25.0	-	1,500,000	13.0	-
28, . . .	2,700	1,600,000	25.0	5	1,520,000	14.0	13
29, . . .	9,200	1,480,000	29.0	12	1,500,000	16.0	48
30, . . .	1,300	1,560,000	31.0	2	1,500,000	17.0	8

Filters Nos. 37 and 38 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 37.			Filter No. 38.		
		Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. Gallons per Acre Daily.	Loss of Head. Inches.	Bacteria per Cubic Centimeter in Effluent.
July 1, ...	500	1,520,000	32.0	1	1,480,000	19.0	35
2, ...	1,300	1,520,000	31.0	3	1,580,000	18.0	15
3, ...	3,900	1,400,000	-	60	1,400,000	-	70
4, ...	-	0	-	-	0	-	-
5, ...	-	60,000	-	-	0	-	-
6, ...	2,500	1,560,000	22.0	6	1,500,000	18.0	29
7, ...	1,300	1,500,000	28.0	7	1,480,000	20.0	64
8, ...	800	1,560,000	28.0	0	1,800,000	18.0	34
9, ...	1,600	1,580,000	27.0	3	1,480,000	21.0	66
10, ...	3,000	1,560,000	-	4	1,540,000	-	17
11, ...	-	1,600,000	23.0	-	1,540,000	17.0	-
12, ...	800	1,500,000	32.0	4	1,480,000	24.0	9
13, ...	6,100	1,520,000	32.0	6	1,520,000	26.0	5
14, ...	9,300	1,520,000	33.0	3	1,500,000	27.0	19
15, ...	21,900	1,520,000	35.0	10	1,500,000	0.5	13
16, ...	8,200	1,500,000	39.0	-	1,520,000	0.5	-
17, ...	6,000	1,560,000	-	4	1,540,000	-	95
18, ...	-	1,540,000	37.0	-	1,520,000	0.5	-
19, ...	500	1,480,000	46.0	14	1,500,000	2.0	24
20, ...	1,000	1,500,000	48.0	13	1,520,000	3.0	19
21, ...	4,700	1,560,000	49.0	3	1,480,000	5.0	12
22, ...	16,900	1,520,000	49.0	468	1,540,000	7.0	76
23, ...	6,500	1,480,000	54.0	5	1,480,000	9.0	13
24, ...	5,500	1,520,000	-	22	1,500,000	-	23
25, ...	-	1,440,000	61.0	-	1,340,000	17.0	-
26, ...	1,300	800,000	-	276	1,440,000	22.0	192
27, ...	1,100	1,200,000	2.0	18,360*	1,500,000	25.0	18,224
28, ...	2,200	1,560,000	2.5	581	1,500,000	27.0	356
29, ...	3,500	1,560,000	2.5	270	1,460,000	30.0	182
30, ...	1,000	1,560,000	2.5	22	1,540,000	31.0	140
31, ...	1,200	1,000,000	-	6	1,340,000	-	40

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water July 9, 12 M., to July 11, 9 A.M.; July 16, 2 P.M., to July 18, 10 A.M.; July 30, 2.15 P.M., to August 1, 8.50 A.M.

Filters Nos. 37 and 38 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 37.			Filter No. 38.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
August 1, . . .	-	0	-	-	1,520,000	0	-
2, . . .	500	1,340,000	3.0	2,650*	1,540,000	0.5	402
3, . . .	650	1,200,000	-	288	1,520,000	1.5	45
4, . . .	12,000	1,140,000	4.0	46	1,520,000	2.0	-
5, . . .	8,000	1,560,000	5.0	50	1,500,000	3.0	42
6, . . .	6,000	1,560,000	5.5	128	1,480,000	5.0	8
7, . . .	2,000	1,560,000	-	30	1,580,000	-	17
8, . . .	-	1,560,000	5.0	-	1,580,000	4.0	-
9, . . .	1,600	1,520,000	7.5	165	1,520,000	9.0	50
10, . . .	2,200	1,500,000	9.0	167	1,520,000	12.0	80
11, . . .	5,600	1,500,000	10.0	400	1,480,000	16.0	150
12, . . .	1,900	1,500,000	11.0	18	1,500,000	18.0	23
13, . . .	2,000	1,560,000	13.0	60	1,480,000	21.0	60
14, . . .	2,800	1,580,000	15.0	660	1,560,000	18.0	42
15, . . .	-	1,400,000	-	-	1,600,000	15.0	-
16, . . .	1,000	1,480,000	9.0	474	1,440,000	26.0	11
17, . . .	3,000	1,520,000	14.0	138	1,540,000	28.0	50
18, . . .	6,700	1,480,000	17.0	15	1,480,000	29.0	31
19, . . .	1,200	1,560,000	18.0	14	1,540,000	29.0	49
20, . . .	15,600	1,540,000	19.0	35	1,520,000	30.0	49
21, . . .	7,100	1,540,000	-	12	1,620,000	-	55
22, . . .	-	1,520,000	20.0	-	1,920,000	23.0	-
23, . . .	2,400	1,500,000	26.0	12	1,400,000	+	17
24, . . .	10,500	1,560,000	24.0	9	1,460,000	5.0	76
25, . . .	8,000	1,480,000	29.0	42	1,520,000	1.0	86
26, . . .	5,900	1,540,000	30.0	54	1,500,000	2.0	85
27, . . .	7,600	1,520,000	32.0	53	1,480,000	3.0	48
28, . . .	-	1,520,000	-	-	1,540,000	-	-
29, . . .	-	1,540,000	29.0	33	1,580,000	3.5	72
30, . . .	11,400	1,480,000	37.0	39	1,460,000	17.0	39
31, . . .	3,100	1,420,000	45.0	27	1,500,000	24.0	85

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water August 6, 2 P.M., to August 8, 8 A.M.; August 13, 2.15 P.M., to August 15, 9 A.M.; August 20, 2 P.M., to August 22, 9.30 A.M.; August 27, 2 P.M., to August 29, 9.30 A.M.

Filters Nos. 37 and 38 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 37.			Filter No. 38.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
September 1, . .	1,500	1,640,000	44.0	18	1,540,000	25.0	46
2, . .	1,700	1,480,000	49.0	30	1,560,000	24.0	22
3, . .	2,900	1,520,000	56.0	35	1,480,000	30.0	90
4, . .	8,800	1,520,000	-	10	1,580,000	-	32
5, . .	-	1,520,000	57.0	-	1,660,000	24.0	-
6, . .	-	1,520,000	56.0	-	1,460,000	27.0	-
7, . .	1,800	1,440,000	63.0	22	1,360,000	+	25
8, . .	16,200	1,460,000	67.0	9	1,400,000	+	35
9, . .	18,700	1,440,000	69.0	14	1,340,000	+	28
10, . .	7,900	1,460,000	71.0	5	1,520,000	1.0	90
11, . .	12,800	1,600,000	+	8	1,480,000	-	140
12, . .	-	1,520,000	+	-	1,460,000	4.0	-
13, . .	6,000	1,480,000	+	6	1,520,000	5.0	21
14, . .	7,500	1,380,000	+	9	1,500,000	6.0	22
15, . .	10,800	1,280,000	+	8	1,500,000	7.0	33

City water was applied instead of river water September 3, 2.30 P.M., to September 6, 8 A.M.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 37.				Filter No. 38.			
			Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	
	Water Bacteria.	Bacillus Prodigiosus.			Water Bacteria.	Bacillus Prodigiosus.			Water Bacteria.	Bacillus Prodigiosus.
September 16,	-	0	1,300,000	+	-	-	1,480,000	10	-	-
17,	18,200	1,000	1,440,000	3	81	1.00	1,520,000	13	109	0.25
18,	4,400	350	1,520,000	-	59	0	1,500,000	-	35	0.25
19,	-	0	1,500,000	2.5	-	-	800,000	+	-	-
20,	1,400	2,000	1,500,000	3	47	0	1,500,000	3.5	52	0.75
21,	6,600	7,500	1,500,000	3.5	19	0.50	1,500,000	3.5	23	13.50
22,	23,000	7,500	1,500,000	4.5	33	0.25	1,520,000	2	39	4.50
23,	23,000	6,800	1,480,000	10	24	1.00	1,520,000	3	54	6.50
24,	5,200	8,300	1,540,000	17	58	0.25	1,480,000	5	39	2.50
25,	19,000	6,500	1,500,000	-	42	1.00	1,580,000	-	193	1.25
26,	-	0	1,400,000	26	-	-	1,600,000	3.5	-	-
27,	6,000	3,000	1,560,000	34	24	2.00	1,540,000	7	41	3.00
28,	8,000	4,000	1,520,000	38	75	1.50	1,500,000	11	79	18.00
29,	46,000	5,300	1,580,000	42	98	0	1,500,000	14	364	9.00
30,	44,000	2,200	1,520,000	48	100	0.50	1,560,000	16	643	10.00

City water was applied instead of river water September 25, 8.45 A.M., to September 26, 9 A.M.

Filters Nos. 37 and 38 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 37.				Filter No. 38.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacillus Prodigiosus.
October, 1,	44,000	2,500	1,540,000	50	87	0	1,500,000	18	277	4.00
2,	28,000	2,700	1,500,000	-	31	1.00	1,500,000	-	186	4.00
3,	-	0	1,440,000	53	-	-	1,480,000	21	-	-
4,	18,000	3,700	1,500,000	58	40	0	1,580,000	21	78	3.75
5,	14,000	3,200	1,540,000	64	20	0.75	1,560,000	23	83	7.00
6,	23,000	4,600	1,500,000	70	50	0.50	1,500,000	27	84	8.00
7,	1,300	4,000	1,640,000	65	60	0.75	1,600,000	29	112	3.00
8,	19,600	2,400	1,980,000	4	58	10.70	2,020,000	+	64	5.30
9,	14,000	3,000	2,040,000	-	152	30.00	2,000,000	-	118	10.30
10,	-	0	2,020,000	4	-	-	2,400,000	+	-	-
11,	10,000	1,500	2,020,000	4.5	59	9.70	1,740,000	+	36	2.30
12,	11,000	2,800	1,980,000	6	36	1.70	1,940,000	1.5	118	4.30
13,	10,000	1,000	2,060,000	12	29	1.00	1,980,000	3	206	3.20
14,	11,000	500	2,020,000	13	40	1.00	1,980,000	6	145	4.50
15,	21,000	350	2,000,000	15	69	1.00	2,060,000	8	105	1.30
16,	18,000	3,500	2,020,000	-	33	0	2,040,000	-	53	0.80
17,	-	0	2,000,000	18	-	-	2,000,000	8	-	-
18,	15,000	1,000	2,060,000	26	40	0.30	2,020,000	14	18	0.50
19,	4,100	2,300	1,980,000	36	21	0.30	2,000,000	17	18	0.50
20,	10,000	5,000	2,040,000	46	25	0.30	2,000,000	23	16	1.00
21,	4,200	1,700	2,040,000	54	27	0.70	1,960,000	29	17	0.50
22,	5,000	670	2,060,000	60	28	0	1,760,000	+	22	1.50
23,	16,000	3,300	2,060,000	-	24	0	2,100,000	-	51	1.80
24,	-	0	1,980,000	63	-	-	2,100,000	2	-	-
25,	6,300	2,700	1,920,000	+	20	0	2,080,000	3	15	0.80
26,	3,600	8,000	1,920,000	+	39	0	2,020,000	5	28	0
27,	8,000	3,400	2,000,000	3.5	24	1.00	2,000,000	8	25	0.30
28,	5,300	3,000	2,100,000	3.5	44	0.30	2,000,000	10	38	1.00
29,	9,800	0	2,080,000	4	50	1.00	2,020,000	12	27	0
30,	5,500	0	2,080,000	-	51	0	2,020,000	-	44	0
31,	-	0	2,060,000	4	-	-	1,980,000	13	-	-

† City water was applied instead of river water October 6, 2.30 P.M., to October 7, 8.10 A.M.; October 8, 3.30 P.M., to October 10, 8.30 A.M.

Filters Nos. 37 and 38 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 37.				Filter No. 38.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
November, 1, .	18,000	0	2,040,000	5	10	-	2,020,000	15	23	-
2, .	17,000	0	2,000,000	6	44	-	2,020,000	19	47	-
3, .	13,000	0	2,060,000	7	31	-	2,080,000	22	20	-
4, .	14,000	0	2,100,000	8	76	-	1,980,000	27	17	-
5, .	17,000	0	2,020,000	9	50	-	1,900,000	+	41	-
6, .	27,000	0	1,980,000	-	45	-	1,800,000	-	70	-
7, .	-	0	1,940,000	12	-	-	1,260,000	+	-	-
8, .	16,000	0	2,040,000	12	48	-	2,060,000	2	85	-
9, .	8,000	0	2,020,000	14	64	-	2,060,000	2	90	-
10, .	13,000	0	2,000,000	16	21	-	2,060,000	3	93	-
11, .	23,000	0	1,960,000	19	34	-	2,040,000	3	31	-
12, .	22,000	0	2,060,000	22	8	-	2,000,000	4	59	-
13, .	28,000	0	2,000,000	-	45	-	2,080,000	-	86	-
14, .	-	0	1,960,000	28	-	-	2,060,000	7	-	-
15, .	12,500	0	2,100,000	29	34	-	2,020,000	8	47	-
16, .	7,200	0	2,040,000	31	55	-	2,020,000	10	8	-
17, .	4,800	0	1,980,000	37	23	-	1,980,000	13	32	-
18, .	5,200	0	2,020,000	42	22	-	1,980,000	20	62	-
19, .	8,600	0	1,960,000	50	48	-	1,900,000	+	48	-
20, .	9,800	0	2,100,000	-	20	-	2,040,000	-	77	-
21, .	-	0	2,200,000	46	-	-	2,000,000	3	-	-
22, .	5,000	5,000	2,000,000	55	22	-	3,000,000	9	23	0.8
23, .	3,400	4,000	2,040,000	58	18	-	3,000,000	13	15	2.5
24, .	3,000	10,000	2,000,000	63	*	-	2,960,000	19	24	2.5
25, .	1,500	3,000	2,440,000	45	32	-	2,980,000	21	18	2.0
26, .	4,000	9,000	1,860,000	72	12	-	2,980,000	29	20	12.5
27, .	4,300	12,000	2,000,000	-	17	-	3,000,000	-	80	14.5
28, .	-	0	1,620,000	+	-	-	2,120,000	+	-	-
29, .	2,300	10,000	2,000,000	7	7	-	3,000,000	5	75	20.0
30, .	2,600	13,000	2,060,000	7	9	-	3,020,000	6	111	21.0

* Liquefied.

City water was applied instead of river water November 24, 8 A.M., to November 25, 8 A.M.

November 22–30 B. prodigiosus was applied to No. 38 but not to No. 37.

Filters Nos. 37 and 38 — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 37.				Filter No. 38.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
December 1, .	4,800	11,000	2,080,000	7	66	-	2,960,000	9	145	66.0
2, .	4,200	3,000	2,020,000	6.5	92	-	3,000,000	13	127	73.0
3, .	3,200	9,000	2,020,000	6.5	120	-	2,960,000	18	110	70.0
4, .	2,800	9,000	2,000,000	-	56	-	3,000,000	-	120	50.0
5, .	-	0	2,000,000	6	-	-	2,560,000	28	-	-
6, .	6,000	2,000	2,000,000	6	49	-	2,600,000	+	380	70.0
7, .	4,800	3,500	2,000,000	6.5	30	-	2,980,000	6	83	17.0
8, .	4,500	6,000	2,000,000	8	42	-	2,980,000	8	30	7.8
9, .	4,700	5,000	2,040,000	10	11	-	3,020,000	13	20	3.8
10, .	11,400	12,000	2,020,000	12	38	-	3,040,000	16	125	3.3
11, .	6,700	6,000	2,040,000	-	38	-	3,000,000	-	57	3.0
12, .	-	0	2,020,000	10	-	-	2,800,000	$\frac{21}{5}$	-	-
13, .	4,200	7,000	1,980,000	15	21	-	500,000	10	162	1.8
14, .	4,100	6,000	2,000,000	17	116	-	520,000	10	78	0.8
15, .	5,000	6,000	2,060,000	20	48	-	500,000	10	56	0.8
16, .	4,100	5,000	2,040,000	19	6	-	500,000	10	74	0.5
17, .	4,500	7,000	2,040,000	20	38	-	500,000	11	29	1.0
18, .	1,800	6,000	2,060,000	-	43	-	520,000	-	20	0
19, .	-	0	2,020,000	27	-	-	500,000	12	-	-
20, .	7,800	3,000	2,000,000	31	43	-	500,000	12	18	0.5
21, .	10,300	6,000	2,060,000	18	70	-	520,000	9	128	0.5
22, .	6,600	3,000	2,000,000	18	32	-	520,000	11	35	0
23, .	6,300	4,000	2,000,000	17	13	-	520,000	7	19	0
24, .	8,500	6,000	1,320,000	-	10	-	360,000	-	20	0.5
25, .	-	0	0	-	-	-	0	-	-	-
26, .	-	0	0	-	-	-	0	-	-	-
27, .	-	0	0	-	-	-	0	-	-	-
28, .	14,000	0	1,300,000	10	100	-	380,000	3	118	0
29, .	11,000	1,000	1,880,000	42	540	-	540,000	7	178	0.5
30, .	18,000	3,000	1,740,000	68	780	-	480,000	10	58	0.8
31, .	11,700	3,000	1,940,000	+	1,158	-	500,000	13	90	1.8

Water pipe was frozen December 25–27. Channels were found at sides of the filters (see page 477). B. prodigiosus was applied to No. 38 but not to No. 37.

Filters Nos. 39 and 40.

[These filters each contained one foot of the same material; No. 40 contained a layer of loam one inch thick eleven inches below the surface. They were both operated continuously.]

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 39.			Filter No. 40.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
June 1, ...	500	1,640,000	-	-	1,500,000	-	-
2, ...	6,500	1,480,000	-	-	1,540,000	-	-
3, ...	1,800	1,520,000	-	-	1,640,000	-	-
4, ...	2,100	1,500,000	-	-	1,520,000	-	-
5, ...	2,700	1,440,000	-	-	1,500,000	-	-
6, ...	-	1,200,000	-	-	1,400,000	-	-
7, ...	1,100	1,400,000	-	93	1,440,000	-	39
8, ...	5,200	1,400,000	-	144	1,500,000	-	128
9, ...	4,500	1,240,000	-	33	1,560,000	-	26
10, ...	4,400	840,000	-	6	1,520,000	-	9
11, ...	4,000	680,000	23.	4	1,400,000	13.5	10
12, ...	3,500	600,000	-	7	1,300,000	-	6
13, ...	-	0	+	-	0	1.0	-
14, ...	1,300	800,000	+	54	1,480,000	7.5	40
15, ...	12,600	1,000,000	-	11	1,600,000	4.5	78
16, ...	2,600	1,540,000	2.0	224	1,400,000	6.5	100
17, ...	18,000	1,480,000	3.5	270	1,500,000	9.0	108
18, ...	14,500	1,520,000	6.0	72	1,480,000	11.0	58
19, ...	17,100	1,520,000	-	46	1,500,000	-	46
20, ...	-	1,360,000	10.5	-	1,240,000	14.0	-
21, ...	1,100	1,520,000	7.0	155	1,520,000	7.0	44
22, ...	11,700	1,480,000	10.0	17	1,480,000	11.0	109
23, ...	3,700	1,460,000	13.0	29	1,400,000	15.0	25
24, ...	2,700	1,460,000	15.0	32	1,460,000	18.0	52
25, ...	2,700	1,500,000	18.0	69	1,500,000	1.0	140
26, ...	2,600	1,520,000	0.5	63	1,560,000	-	106
27, ...	-	1,500,000	1.0	-	1,540,000	3.0	-
28, ...	2,700	1,480,000	2.5	34	1,520,000	5.0	21
29, ...	9,200	1,500,000	4.0	22	1,460,000	8.0	17
30, ...	1,300	1,480,000	9.0	6	1,400,000	16.0	16

Filters Nos. 39 and 40 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 39.			Filter No. 40.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
July 1, . . .	500	1,480,000	13.0	6	1,480,000	1.0	8
2, . . .	1,300	1,480,000	17.0	17	1,520,000	1.0	1
3, . . .	3,900	1,400,000	-	106	1,400,000	-	26
4, . . .	-	0	-	-	0	-	-
5, . . .	-	0	-	-	0	-	-
6, . . .	2,500	1,320,000	20.	318	1,520,000	4.0	17
7, . . .	1,300	1,520,000	1.	15	1,500,000	9.0	10
8, . . .	800	1,520,000	1.5	10	1,500,000	11.0	15
9, . . .	1,600	1,520,000	2.5	12	1,480,000	14.0	19
10, . . .	3,000	1,520,000	-	10	1,600,000	-	14
11, . . .	-	1,520,000	2.5	-	1,640,000	8.0	-
12, . . .	800	1,980,000	7.0	6	1,020,000	12.0	6
13, . . .	6,100	1,920,000	10.0	8	960,000	15.0	3
14, . . .	9,300	1,940,000	14.0	7	980,000	17.0	8
15, . . .	21,900	2,100,000	1.5	53	1,020,000	0.5	24
16, . . .	8,200	2,000,000	3.0	60	1,000,000	0.5	61
17, . . .	6,000	2,080,000	-	19	1,000,000	-	18
18, . . .	-	2,160,000	2.5	-	1,000,000	0.5	-
19, . . .	500	2,000,000	6.0	27	980,000	1.5	10
20, . . .	1,000	2,000,000	8.0	29	1,000,000	2.0	11
21, . . .	4,700	1,940,000	12.0	13	980,000	3.5	6
22, . . .	16,900	1,960,000	16.0	36	1,000,000	4.5	166
23, . . .	6,500	1,840,000	20.0	10	1,000,000	6.0	10
24, . . .	5,500	2,040,000	-	18	1,020,000	-	13
25, . . .	-	1,980,000	3.5	-	980,000	9.0	-
26, . . .	1,300	1,920,000	5.5	17	940,000	11.0	67
27, . . .	1,100	2,100,000	7.0	23	960,000	15.0	910
28, . . .	2,200	1,920,000	11.0	26	1,000,000	17.0	258
29, . . .	3,500	1,980,000	17.0	112	920,000	+	2,178*
30, . . .	1,000	1,980,000	+	92	1,000,000	+	686
31, . . .	1,200	1,800,000	-	206	900,000	-	270

* Numbers above 500 do not appear in the averages (see page 530).

City water was applied instead of river water July 9, 12 M., to July 11, 9 A.M.; July 16, 2 P.M., to July 18, 10 A.M.; July 30, 2.15 P.M., to August 1, 8.50 A.M.

Filters Nos. 39 and 40 — Continued.

DATE — 1892.	Bacteria per Cubic Centimeter in Applied Water.	FILTER No. 39.			FILTER No. 40.		
		Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent.
August 1, . .	-	2,040,000	1.0	-	1,020,000	0	-
2, . .	500	2,020,000	2.5	37	1,020,000	0	570*
3, . .	650	2,040,000	2.0	31	1,020,000	0	396†
4, . .	12,000	2,000,000	4.0	132	1,020,000	0.5	2,698
5, . .	8,000	1,960,000	7.0	1,160	1,020,000	1.0	1,296
6, . .	6,000	1,900,000	11.0	‡	1,000,000	2.0	‡
7, . .	2,000	2,220,000	-	35	960,000	-	120
8, . .	-	2,260,000	9.0	-	940,000	1.5	-
9, . .	1,600	1,840,000	18.0	54	920,000	3.5	224
10, . .	2,200	1,820,000	+	57	960,000	5.0	214
11, . .	5,600	1,940,000	2.0	150	960,000	6.0	65
12, . .	1,900	1,960,000	4.0	110	980,000	8.0	23
13, . .	2,000	2,160,000	7.0	39	1,020,000	9.0	135
14, . .	2,800	2,080,000	6.0	30	960,000	7.0	103
15, . .	-	2,140,000	5.0	-	1,000,000	6.0	-
16, . .	1,000	1,980,000	12.0	8	960,000	12.0	7
17, . .	3,000	1,920,000	18.0	-	960,000	15.0	26
18, . .	6,700	1,920,000	+	25	980,000	15.0	12
19, . .	1,200	1,740,000	1.0	22	1,000,000	17.0	27
20, . .	15,600	2,000,000	2.5	80	960,000	19.0	47
21, . .	7,100	2,040,000	-	43	1,040,000	-	32
22, . .	-	2,120,000	2.5	-	1,220,000	15.0	-
23, . .	2,400	1,960,000	6.0	35	900,000	+	27
24, . .	10,500	1,960,000	11.0	36	960,000	0.5	60
25, . .	8,000	1,880,000	17.0	63	980,000	0.5	42
26, . .	5,900	1,720,000	+	86	1,020,000	1.0	55
27, . .	7,600	2,180,000	2.0	101	1,000,000	1.0	49
28, . .	-	2,040,000	-	-	1,020,000	-	-
29, . .	-	1,900,000	2.0	89	1.040,000	1.0	39
30, . .	11,400	1,820,000	15.0	50	940,000	4.0	25
31, . .	3,100	1,600,000	+	80	960,000	7.0	87

* Numbers above 500 do not appear in the averages (see page 530).

† These filters were scraped on August 2 to remove substances accidentally spilled upon them.

‡ Liquefied.

In those cases where the loss of head is recorded as 0 the zero mark probably did not correspond with the level of the water in filter. The loss of head was probably less than one inch, however.

City water was applied instead of river water August 6, 2 P.M., to August 8, 8 A.M.; August 13, 2.15 P.M., to August 15, 9 A.M.; August 20, 2 P.M., to August 22, 9.30 A.M.; August 27, 2 P.M., to August 29, 9.30 A.M.

Filters Nos. 39 and 40 — Continued.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.	Filter No. 39. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 39. Loss of Head. — Inches.	Filter No. 39. Bacteria per Cubic Centimeter in Effluent.	Filter No. 40. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 40. Loss of Head. — Inches.	Filter No. 40. Bacteria per Cubic Centimeter in Effluent.
September 1, . .	1,500	2,100,000	1.5	6,150*	1,040,000	8.0	3,495
2, . .	1,700	2,000,000	2.5	27	960,000	9.0	40
3, . .	2,900	1,960,000	4.0	62	980,000	12.00	55
4, . .	8,800	2,040,000	-	40	1,020,000	-	35
5, . .	-	2,040,000	5.0	-	960,000	12.0	-
6, . .	-	2,040,000	5.0	-	1,000,000	13.0	-
7, . .	1,800	1,800,000	14.0	25	940,000	18.0	35
8, . .	16,200	1,980,000	19.0	65	940,000	+	35
9, . .	18,700	1,860,000	+	140	980,000	+	84
10, . .	7,900	2,020,000	2.0	60	1,020,000	0.5	140
11, . .	12.800	2,020,000	-	36	1,000,000	-	38
12, . .	-	1,980,000	6.0	-	960,000	1.5	-
13, . .	6,000	2,040,000	8.0	24	1,020,000	2.5	11
14, . .	7,500	2,000,000	9.0	24	980,000	3.0	16
15, . .	10,800	2,000,000	11.0	28	1,000,000	3.5	29

* Numbers above 500 do not appear in the averages (see page 530).
City water was applied instead of river water September 3, 2.30 P.M., to September 6, 8 A.M.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water. Water Bacteria.	Bacteria per Cubic Centimeter in Applied Water. Bacillus Prodigiosus.	Filter No. 39. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 39. Loss of Head. — Inches.	Filter No. 39. Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Filter No. 39. Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Filter No. 40. Rate of Filtration. — Gallons per Acre Daily.	Filter No. 40. Loss of Head. — Inches.	Filter No. 40. Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Filter No. 40. Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
September 16,	-	0	1,940,000	17	-	-	1,000,000	5	-	-
17,	18,200	1,000	1,920,000	+	45	0	1,020,000	6	35	0
18,	4,400	350	1,400,000	+	17	0	1,000,000	-	23	0
19,	-	0	900,000	+	-	-	860,000	12	-	-
20,	1,400	2,000	2,000,000	1.5	51	0.75	1,000,000	11	25	0
21,	6,600	7,500	2,040,000	4	68	15.50	1,000,000	13	6	1.50
22,	23,000	7,500	1,980,000	8	306	4.75	980,000	17	48	7.75
23,	23,000	6,800	1,980,000	13	60	.9.50	1,000,000	+	64	17.25
24,	5,200	8,300	1,940,000	+	62	6.75	960,000	+	57	25.00
25,	19,000	6,500	2,040,000	-	119	1.25	960,000	-	61	0.50
26,	-	0	1,980,000	+	-	-	840,000	+	-	-
27,	6,000	3,000	1,300,000	+	41	4.00	1,000,000	0.5	42	1.00
28,	8,000	4,000	2,000,000	2	75	10.00	1,000,000	1	20	3.00
29,	46,000	5,300	1,980,000	4	124	5.00	1,000,000	3	43	2.40
30,	44,000	2,200	2,000,000	8	190	2.00	980,000	4	37	0.50

City water was applied instead of river water September 25, 8.45 A.M., to September 26, 9 A.M.

Filters No. 39 — Continued; *and No. 40* — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 39.				Filter No. 40.			
					Bacteria per Cubic Centimeter in Effluent.				Bacteria per Cubic Centimeter in Effluent.	
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Water Bacteria.	Bacillus Prodigiosus.
October 1, .	44,000	2,500	2,000,000	11	63	4.00	1,000,000	6	67	4.00
2, .	28,000	2,700	1,000,000	-	46	1.00	1,980,000	-	73	1.3
3, .	-	0	980,000	12	-	-	1,800,000	14	-	-
4, .	18,000	3,700	1,000,000	13	24	0.75	2,020,000	15	70	0.5
5, .	14,000	3,200	940,000	18	109	0.75	1,940,000	+	45	1.5
6, .	23,000	4,600	940,000	+	35	7.00	1,780,000	+	31	2.5
7, .	1,300	4,000	1,000,000	0.5	83	11.00	2,080,000	3	70	1.0
8, .	19,600	2,400	1,000,000	1	36	2.50	2,080,000	5	40	5.8
9, .	14,000	3,000	1,000,000	-	71	2.30	2,120,000	-	41	4.0
10, .	-	0	1,000,000	1.5	-	-	2,140,000	7	-	-
11, .	10,000	1,500	940,000	3	19	1.30	1,960,000	11	37	4.0
12, .	11,000	2,800	1,020,000	4	38	1.00	2,020,000	14	45	2.5
13, .	10,000	1,000	1,000,000	5	39	0.40	1,980,000	17	19	1.8
14, .	11,000	500	980,000	6	41	1.00	1,980,000	+	56	0.8
15, .	21,000	350	1,000,000	7	66	0	1,940,000	+	30	1.3
16, .	18,000	3,500	1,020,000	-	56	0.50	2,100,000	-	56	0.5
17, .	-	0	1,000,000	9	-	-	2,020,000	3	-	-
18, .	15,000	1,000	980,000	13	40	0.50	2,000,000	5	34	0.3
19, .	4,100	2,200	960,000	18	25	1.50	2,060,000	7	10	0
20, .	10,000	5,000	1,000,000	+	28	0	2,020,000	9	16	0
21, .	4,200	1,700	800,000	+	28	0.50	2,020,000	10	14	0.5
22, .	5,000	670	960,000	0.5	19	1.00	2,000,000	13	13	1.5
23, .	16,000	3,300	1,020,000	-	91	2.00	2,000,000	-	20	0
24, .	-	0	1,000,000	0.5	-	-	1,900,000	17	-	-
25, .	6,300	2,700	1,020,000	1	23	0.80	1,920,000	+	12	1.3
26, .	3,600	8,000	1,000,000	2	31	3.30	1,200,000	+	13	0
27, .	8,000	3,400	980,000	3	33	1.00	-	-	-	-
28, .	5,300	3,000	1,020,000	4	26	1.50	-	-	-	-
29, .	9,800	0	1,000,000	4	39	0	-	-	-	-
30, .	5,500	0	1,000,000	-	59	0	-	-	-	-
31, .	-	0	1,000,000	5	-	-	-	-	-	-

Filter No. 40 was emptied on October 26.

City water was applied instead of river water October 6, 2.30 P.M., to October 7, 8.10 A.M.; October 8, 3.30 P.M., to October 10, 8.30 A.M.

Filters No. 39 — Continued; *and No. 42.*

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 39.				Filter No. 42.			
	Water Bacteria.	Bacillus Prodigiosus	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
November 1, .	18,000	17,000	2,080,000	9.	36	5.30	2,040,000	2.	385	0
2, .	17,000	13,000	2,020,000	12.	16	7.50	2,020,000	3.	177	1.3
3, .	13,000	3,000	1,940,000	16.	55	5.50	1,940,000	4.	450	2.3
4, .	10,000	16,000	1,960,000	+	70	6.50	2,020,000	7.	200	34.5
5, .	12,000	16,000	1,840,000	+	68	5.30	2,000,000	9.	134	16.3
6, .	27,000	13,500	2,000,000	-	217	6.50	2,000,000	-	263	5.5
7, .	-	0	1,940,000	4.	-	-	1,900,000	13.	-	-
8, .	16,000	9,000	2,020,000	7.	157	8.50	1,980,000	17.	108	8.0
9, .	8,000	12,000	1,980,000	12.	65	4.50	1,960,000	+	134	11.8
10, .	13,000	16,000	1,940,000	17.	44	7.00	1,940,000	+	245	48.5
11, .	23,000	14,000	1,900,000	+	60	6.00	1,840,000	1.	400	69.8
12, .	22,000	17,000	1,760,000	+	96	5.00	2,000,000	2.	293	29.3
13, .	28,000	10,000	1,960,000	-	134	25.50	2,080,000	-	112	18.8
14, .	-	0	2,000,000	3.	-	-	2,040,000	5.	-	-
15, .	12,500	18,000	2,000,000	5.	125	6.30	1,980,000	8.	110	2.5
16, .	7,200	10,000	2,000,000	8.	40	4.00	1,920,000	13.	62	2.5
17, .	4,800	2,300	1,940,000	12.	40	5.00	1,860,000	19.	77	2.3
18, .	5,200	17,000	1,780,000	+	31	2.50	1,440,000	+	58	4.0
19, .	8,600	10,000	1,940,000	8.	54	4.50	2,000,000	3.	82	22.0
20, .	9,800	6,000	2,100,000	-	70	6.30	2,000,000	-	317	36.0
21, .	-	0	2,200,000	8.	-	-	1,960,000	4.	-	-
22, .	5,000	5,000	2,860,000	+	36	4.80	2,200,000	5.	153	14.8
23, .	3,400	4,000	3,000,000	5.	99	7.00	2,980,000	10.	120	13.5
24, .	3,000	10,000	3,020,000	7.	52	8.00	3,140,000	13.	75	12.8
25, .	1,500	3,000	2,960,000	9.	37	9.00	2,880,000	16.	185	17.0
26, .	4,000	9,000	2,940,000	14.	36	23.00	3,280,000	15.	238	45.0
27, .	4,300	12,000	3,000,000	-	75	80.00	3,000,000	-	984	132.0
28, .	-	0	2,440,000	+	-	-	2,500,000	+	-	-
29, .	2,300	10,000	3,000,000	5.	223	70.00	3,000,000	6.	325	87.0
30, .	2,600	13,000	2,980,000	7.	269	91.00	3,040,000	7.	452	80.0

Filter No. 42 contained one foot of the same material as No. 39 and was operated continuously. City water was applied instead of river water November 24, 8 A.M., to November 25, 8 A.M.

Filters Nos. 39 and 42 — Concluded.

Date — 1892.	Bacteria per Cubic Centimeter in Applied Water.		Filter No. 39.				Filter No. 42.			
	Water Bacteria.	Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.	Rate of Filtration. — Gallons per Acre Daily.	Loss of Head. — Inches.	Bacteria per Cubic Centimeter in Effluent. Water Bacteria.	Bacteria per Cubic Centimeter in Effluent. Bacillus Prodigiosus.
December 1, .	4,800	11,000	2,980,000	10.	340	88.00	3,020,000	8.	567	78.0
2, .	4,200	3,000	2,840,000	14.	155	110.00	3,020,000	10.	157	137.0
3, .	3,200	9,000	2,860,000	+	232	110.00	2,960,000	14.	147	90.0
4, .	2,800	9,000	2,800,000	+	237	102.00	2,920,000	-	140	60.0
5, .	-	0	2,360,000	+	-	-	2,800,000	20.	-	-
6, .	6,000	2,000	3,000,000	6.	172	33.00	2,960,000	+	25	10.0
7, .	4,800	3,500	3,000,000	8.	113	15.00	3,000,000	11.	48	13.3
8, .	4,500	6,000	2,960,000	12.	52	8.30	3,000,000	14.	29	4.5
9, .	4,700	5,000	2,800,000	+	41	3.50	2,920,000	20.	22	1.3
10, .	11,400	12,000	2,580,000	+	41	2.80	2,820,000	+	34	2.5
11, .	6,700	6,000	3,040,000	-	50	6.00	3,040,000	-	34	3.0
12, .	-	0	3,000,000	5.	-	-	3,160,000	8.	-	-
13, .	4,200	7,000	520,000	1.	22	0.80	520,000	0.5	16	0.3
14, .	4,100	6,000	520,000	1.5	47	0.30	540,000	0.5	12	0.5
15, .	5,000	6,000	500,000	2.	26	0.50	520,000	0.5	22	0.0
16, .	4,100	5,000	500,000	3.	11	0.00	500,000	0.5	17	0.0
17, .	4,500	7,000	500,000	4.	7	1.00	480,000	0.5	22	0.0
18, .	1,800	6,000	520,000	-	10	0.50	520,000	-	20	0.3
19, .	-	0	500,000	5.	-	-	500,000	0	-	-
20, .	7,800	3,000	500,000	6.	25	1.00	540,000	0	23	0.3
21, .	10,300	6,000	540,000	6.	24	0.30	520,000	0	21	0.0
22, .	6,600	3,000	520,000	6.	16	0.50	520,000	0	37	0.0
23, .	6,300	4,000	540,000	2.	31	0.30	520,000	0	45	1.0
24, .	8,500	6,000	400,000	-	27	0.80	400,000	0	38	1.5
25, .	-	0	0	-	-	-	0	-	-	-
26, .	-	0	0	-	-	-	0	-	-	-
27, .	-	0	0	-	-	-	0	-	-	-
28, .	14,000	0	360,000	2.	366	3.00	360,000	0	98	0.0
29, .	11,000	1,000	500,000	4.	86	1.00	500,000	0	86	1.3
30, .	18,000	3,000	540,000	7.	49	1.30	520,000	0	49	2.0
31, .	11,700	3,000	500,000	10.	34	0.00	500,000	0	55	0.5

Water pipe was frozen December 25-27. Channels were formed at sides of filters (see page 477).

Special Biological Work Relating to the Purification of Water by Sand Filtration.

During the past year several bacteriological problems have arisen which have had a direct bearing upon the subject of water purification. Some of the more important of these are described in the following pages.

Removal of Living Bacteria from Water during its Passage through an Iron Pipe.

In August, 1891, a one-inch iron pipe about 350 feet long was laid from the canal to the upper end of the station. A continuation of this pipe extended about 150 feet into the station. Throughout 1891 no difference was observed in the number of bacteria in the water taken direct from the canal and after its passage through this pipe. A decrease, however, began to show itself during the following winter, and became very marked after the spring freshets occurred, as is shown by the table below.

On May 21, 1892, this pipe was replaced by a two-inch galvanized-iron pipe as far as to its entrance to the station. A valve at this point was kept partly open, allowing a rapid flow of water through the pipe, to prevent the accumulation of sediment, and no decrease in the number of water bacteria upon passage through this pipe has been observed during the following thirteen months. When the small iron pipe was removed it was found to contain a large amount of sediment and iron rust. The continuation of this small iron pipe in the station, 150 feet long, remained in service throughout the year. There was in it a gradual accumulation of iron rust and sediment, and from time to time this has been removed by forcing city water through the pipe under high pressure. The effect of cleaning this pipe, upon the bacterial contents of the water, is illustrated by a comparison of the results on December 20 and 27 in the table below : —

Table showing Number of Bacteria per Cubic Centimeter in River Water from Different Points in an Iron Pipe.

Date.	Direct from the Canal.		Tap at Upper End of Station.	Tap at Lower End of Station.
1891.				
Nov. 27,	1,008	-	-	1,120
28,	610	-	-	676
1892.				
April 16,	1,298	-	-	183
19,	1,170	-	-	263
21,	3,213	-	1,158	390
21,	2,952	3,200	714	456
22,	3,132	4,050	644	460
23,	6,200	6,700	1,650	1,128
25,	1,300	1,100	162	94
May 10,	1,698	1,368	168	182
Dec. 20,	12,200	12,000	11,900	6,400
27,	16,800	16,300	16,300	15,000

Comparison of the Duration of Life of Typhoid Fever Germs (of Eberth) in Merrimack River Water before and after Filtration, and after its Passage through the Reservoir and Service Pipes of the Lawrence Water Works.

The results of many experiments upon this problem indicate that the life of these bacteria is slightly shorter in the river water than in the city water and in the effluents of some filters. It is hoped that experiments now in progress will throw more light upon this subject.

The typhoid bacilli experimented upon were grown for four days at 20° C. in a slightly alkaline solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. The water was infected by introducing the germs cultivated in this solution in the proportion of one part in five thousand. The following table shows representative results of these experiments. The temperature was 7° C. In all of the experiments the bottles which were used were chemically clean; and in taking out samples for planting, the pipettes were never placed in the bottles, but a small portion of the water was poured, after shaking, into a sterilized and chemically clean test tube. By this means the introduction of additional organic matter was avoided.

Number of Days after Inoculation.	River Water.		City Water.		Effluent of Filter No. 36 A.	
	Water Bacteria.	*B. typhi abdominalis.*	Water Bacteria.	*B. typhi abdominalis.*	Water Bacteria.	*B. typhi abdominalis.*
0,	6,000	8,000	500	8,000	300	8,000
2,	10,000	6,800	900	8,000	1,100	5,000
5,	2,000	1,600	11,000	4,000	45,000	2,000
9,	900	600	450	500	9,000	800
12,	1,400	Less than 100	1,800	Less than 100	4,800	300
16,	2,000	None.	1,500	11	2,600	19
20,	2,800	None.	500	None.	2,400	None.
25,	1,000	None.	236	None.	800	None.

On the Duration of Life of *B. prodigiosus* in the Different Waters.

The results of experiments made side by side and under similar conditions with those upon *B. typhi abdominalis* indicate that that species of bacteria, also, dies a little more quickly in river water than in city water or filtered river water delivered by (continuous) Filter No. 36 A. In the table below are given the results of a representative experiment which was made side by side with the one which is presented above on the life of typhoid fever germs of Eberth : —

Number of Days after Inoculation.	River Water.		City Water.		Effluent of Filter No. 36 A.	
	Water Bacteria.	B. prodigiosus.	Water Bacteria.	B. prodigiosus.	Water Bacteria.	B. prodigiosus.
0,	6,000	2,200	500	2,900	300	2,800
2,	10,800	700	2,700	1,800	2,000	900
5,	3,000	100	5,000	1,500	39,000	1,200
9,	690	19	912	107	8,500	95
12,	1,220	16	1,800	87	5,500	61
16,	585	3	976	22	6,600	7
20,	710	None.	714	None.	700	None.
25,	718	None.	585	None.	1,288	None.

Comparison of the Duration of Life in Water of *B. typhi abdominalis* and *B. prodigiosus*.

Numerous experiments in addition to those which have been presented indicate that the life histories of these two germs in water are very similar. Neither species appears to grow in the waters tested, but both continue to live, in gradually decreasing numbers, for a period of from fifteen to twenty days. In these experiments the longest duration of life observed of Eberth bacilli was twenty-four days, and of *B. prodigiosus* thirty-one days.

Description of the Method of Application of *B. prodigiosus* to the Water Filters.

A pure culture of this species of bacteria was obtained by inoculation and growth for four days at 20° C. in a solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. It was found that this solution on an average contained 20,000,000 *B. prodigiosus* per cubic centimeter. This solution was applied to the filters in the proportion of one part to three thousand parts of water, at intervals of one or two hours, according to the rate of filtration. Every cubic centimeter of water which went into the filter contained, as a rule, about 7,000 *B. prodigiosus* in addition to the water bacteria ordinarily present. It was determined also that the food material which was applied with these germs did not increase the organic matter in the river water beyond the limits of variation which have been occasionally observed in it from month to month. The following table contains the average results of five analyses of the river water before and after adding to it this solution : —

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
River water before inoculation, ...	.0056	.0172	0.19	.015	.0001	0.52
River water after inoculation, ...	.0062	.0203	0.19	.015	.0001	0.54

Repeated determinations have been made of the persistence of life of *B. prodigiosus* in the water which was actually applied to the filters, and this germ was found to live in diminished numbers for fifteen to twenty days. There appears to be no reason to believe that any of these germs die before reaching the sand. The conditions for the persistence of life of the bacteria in the laboratory experiments are probably somewhat different from those which would be found in large bodies of water where there would be more or less mingling of the germs with a fresh supply of water which might bring to them more available food material. Throughout these experiments, September 16 to December 31, four examinations were made daily of each of the effluents, at a time when the water from the applied doses was passing through the outlet-pipes.

Effect of Summer Weather upon the Efficiency of Filters in the Removal of Bacteria.

The statistics in the tables (pp. 490–525) show that all of the effluents at times contained very large numbers of bacteria during July and August. In some cases they equalled and even exceeded the number applied. This was least noticeable in case of the intermittent filters Nos. 35 A and 41. Some error in the process of determination was at first suggested as the reason for this. Detailed study of the conditions under which the examinations were made, however, together with the results of more numerous examinations, indicated that this was not so. It then appeared that there must be present in the filters at times conditions which favored the growth of certain kinds of bacteria.

It has just been shown that Eberth bacilli and *B. prodigiosus* do not appear to multiply in the Merrimack River water. These germs were applied to Filters Nos. 39 and 40, which were operated at rates of 2,000,000 and 1,000,000 gallons, respectively, with the following results: —

Removal of Bacillus prodigiosus by (Continuous) Filters No. 39 and No. 40.

On July 28 frequent applications of *B. prodigiosus* solution were made, so that the applied water contained 770 bacteria of this species per cubic centimeter for ten hours. The number of water bacteria was 3,500 per cubic centimeter.

Date — 1892.	Hour.	Effluent from Filter No. 39.		Effluent from Filter No. 40.	
		Water Bacteria per Cubic Centimeter.	B. prodigiosus per Cubic Centimeter.	Water Bacteria per Cubic Centimeter.	B. prodigiosus per Cubic Centimeter.
July 28,	11.00	55	0	512	0
28,	1.00	32	3	354	0
28,	2.00	448	0	504	0
28,	3.00	64	1	698	1
28,	4.00	92	1	684	0
28,	6.00	112	3	480	0
28,	9.00	63	0	1,090	0
29,	5.30	89	0	156	0
29,	8.30	92	0	686	0
29,	5.15	126	0	122	0
30,	8.30	206	0	270	0
30,	3.00	276	0	516	0

These results indicate a removal of 99.81 and 99.99 per cent., respectively, of the applied *B. prodigiosus*, while of water bacteria, which averaged 1,900 per cubic centimeter during this time, there were apparently removed only 92.3 and 77.9 per cent., respectively. It must be remembered, however, that the filters, as has been shown on p. 459, are charged with water bacteria, so that the actual removal of those applied was probably much greater than these percentages indicate.

Removal of Bacillus typhi abdominalis by (Continuous) Filters No. 39 and No. 40.

On August 4 Eberth bacilli were applied to these two filters in a manner similar to that described above. During the ten hours of application the applied water contained 15,000 typhoid bacilli per cubic centimeter. The number of ordinary bacteria present in the river water on this date was 8,000 per cubic centimeter.

Date — 1892.	Hour.	Effluent from Filter No. 39.		Effluent from Filter No. 40.	
		Water Bacteria per Cubic Centimeter.	B. typhi abdom. per Cubic Centimeter.	Water Bacteria per Cubic Centimeter.	B. typhi abdom. per Cubic Centimeter.
Aug. 4, ...	11.00	32	0	11	2
4, ...	1.00	188	19	15	0
4, ...	3.00	45	8	15	0
4, ...	5.00	45	5	15	2
4, ...	7.00	26	0	1,035	0
4, ...	9.00	61	12	21	2

This table shows a removal by Filters Nos. 39 and 40 of 99.94 and 99.99 per cent., respectively, of the applied typhoid bacilli, and 99.19 and 97.86 per cent. of the water bacteria.

It was determined that the large numbers of bacteria which passed the filters and which developed slowly upon the gelatine plates did not appear in the effluents in the form of spores.

Quantitative species determinations were made on August 18 of the bacteria before and after passage through the several filters. The most characteristic feature of the results was the number of bacteria of a single species, designated in the report for 1891 as "No. 11.0," which were present in the effluents. The results expressed in numbers per cubic centimeter are given in the following table: —

	River Water.	Filter No.								
		33 A.	34 A.	35 A.	36 A.	37	38	39	40	41
Total number of bacteria,	4.400	45	240	9	130	660	42	39	103	34
Number of Species No. 11.0, ...	.900	15	110	6	55	333	25	17	50	22

All other forms of bacteria in the applied water were found, if at all, in very small numbers. There were twenty-three species of bacteria observed in the applied water, while in the effluents there were only from five to eleven species present. Up to July this species had never appeared in the effluents in any such numbers, and all the data taken together pointed very strongly to an unusually long persistence of life, and at times to a growth of this species at some point in the filters.

In studying the life history of this species it was found that species No. 11.0 is one of the hardier forms, which did not show a diminution in the river water during freezing weather, and that it is capable of growth in water, as is shown by the following experiment. In order to learn the length of life of *B. typhi adominalis* in city water, two chemically clean bottles were filled with city water on April 8, and placed in the ice chest (in the dark) at a temperature of 5°–8° C. To bottle No. 2 were added some typhoid germs. The results of quantitative species determinations indicated very clearly the ability of species No. 11.0 to grow under these conditions.

Date — 1892.	Bottle No. 1.		Bottle No. 2.	
	Total Number of Bacteria per Cubic Centimeter.	Species No. 11.0 per Cubic Centimeter.	Total Number of Bacteria per Cubic Centimeter.	Species No. 11.0 per Cubic Centimeter.
April 8, ...	102	5	103	None.
9, ...	90	7	36	None.
11, ...	134	28	40	1
13, ...	2,544	1,854	1,008	378
16, ...	20,600	10,100	66,000	19,500

The question then arose, at what place in the filter do the conditions become favorable for the growth of this species during the high temperature of the summer months? It is not claimed that the conditions were such that a growth of this or any other species

occurred regularly; but, from the high numbers (see statistics, pp. 490–525), there is little doubt that a growth occurred at irregular intervals. There was no opportunity for increasing at this time the organic matter attached to the underdrains and outlet pipes; and, as this species can multiply at a temperature of 5°–8° C., it seems very improbable that a growth would occur there now but not during May and June. In order that the large numbers of bacteria might result from a growth upon the organic matter of the effluent, such a development would have to take place very quickly, for it takes the water less than twelve hours to pass through the filters. Moreover, the following experiments show that the effluents did not contain sufficient organic matter to permit any growth in so short a time: —

Number of Bacteria per Cubic Centimeter in Effluents after Standing at 20° C.

Date — 1892.	Hour.	Filter No. 8.	Filter No. 35 A.	Filter No. 36 A.	Filter No. 39.	Filter No. 40.
Aug. 25, ...	9.30	146	110	120	150	175
25, ...	10.30	75	90	60	100	80
25, ...	11.30	54	66	60	60	109
25, ...	1.30	65	69	72	128	75
25, ...	4.30	56	115	71	150	41
26, ...	9.30	52	126	96	130	76
Sept. 1, ...	12.20	24	-	-	40	48
1, ...	2.00	23	-	-	47	42
1, ...	3.45	32	-	-	58	40
1, ...	5.45	20	-	-	41	50
2, ...	9.00	54	-	-	60	44
2, ...	2.00	62	-	-	36	55

Unfortunately there were no examinations made of the bacterial contents of the deposit on the surface of the filters at the time when bacteria in the effluents indicated this peculiar condition. The results of examinations at a later time are as follows: —

Date — 1892.	Number of Filter.	Method of Operation.	Days since Last Scraping.	Per Cent. which Bacteria formed in Deposit are of Those Applied since Last Scraping.
Sept. 28, ...	34A	Continuous.	9	70
Oct. 8, ...	35A	Intermittent.	19	2
8, ...	41	Intermittent.	6	12
15, ...	40	Continuous.	9	80

Quantitative species determinations indicated that species No. 11.0 formed fifty per cent. of the total bacteria on the surface of intermittent filters, and seventy-five per cent. of those on continuous ones.

From the evidence at hand we may infer: —

1. That during the summer months the temperature or other conditions for continuation of life of bacteria at the surface of filters are more favorable than at any other time.

2. That certain species of bacteria are even able to multiply there at times during this period, although most species rapidly decline.

3. That this is far less noticeable in the case of intermittent than of continuous filters.

4. That typhoid fever germs fail to grow under these conditions, so that the hygienic value of filtration is not affected by the growth during warm weather of a very few species of the more hardy water bacteria.

Distribution of Bacteria, and the Prevalence of Species No. 11, within a Filter.

The following table shows a comparison of the number of bacteria in the sand at different depths of Filter No. 40, which was discontinued on October 26. There is also given the percentages which species No. 11.0 formed of the total number of bacteria. This species of bacteria was the most numerous in the applied river water during August, September and October. At the time of this examination it formed forty per cent. of the bacteria applied to the filter.

Depth of Sample from Surface. — Inches.	Number of Bacteria per Gram.	Per Cent. Which Species No. 11.0 formed of the Total Number of Bacteria.	Depth of Sample from Surface. — Inches.	Number of Bacteria per Gram.	Per Cent. Which Species No. 11.0 formed of the Total Number of Bacteria.
0-¼,	1,100,000	74	2,	21,000	25
½,	320,000	84	4,	4,000	79
1,	140,000	79	6,	1,600	81

Influence of Nitrification upon the Removal of Bacteria by Sand Filters.

It was shown in the Special Report upon Purification of Sewage and Water, 1890 (p. 591), that the number of bacteria was very low in the effluents of those filters having nearly complete nitrification. It was desired to determine whether nitrification, by itself, killed the bacteria, and could be depended upon to render sterile the

effluent of a filter having high nitrification, or whether the conditions favoring nitrification also favored the removal of bacteria, and the two processes were more or less independent. To settle this point, experiments were made upon Filter No. 13, filled with coarse sand of an effective size of 0.48 millimeters which allowed some bacteria to pass through it.

Beginning in April, 1890, ammonium chloride equivalent to 28 parts of nitrogen per 100,000, with sufficient sodium carbonate to form nitrates, has been applied to this filter. Since May 16, 1890, these solutions have been made in the effluents of Filters Nos. 8 or 18 A.

The tables of analyses in the annual report for 1891 (p. 540) and this report (p. 438) indicate that during the greater part of the time there was high nitrification and a thousand times as great as would ordinarily occur in the filtration of a water supply, there being more than a thousand times as much ammonia to be nitrified. The number of bacteria applied to the filter has been very variable, as it was found that bacteria were present in the sodium carbonate solution. The bacteria in the applied dose varied from 30,000 to less than 100 per cubic centimeter. Determinations of the species of bacteria in the effluent showed that the filter was seeded with the most hardy kinds met with at Lawrence, and species which are able to grow upon small amounts of organic matter. In order to learn whether bacteria were able to pass through this filter from top to bottom in the presence of this enormous nitrification, applications of prominent species of bacteria in dilute formular solutions were made, with the following results : —

Results of Bacterial Examinations of Effluent from Filter No. 13.

DATE — 1892.	Hour.	Rate of Flow. Cubic Centimeters per Minute.	Bacteria per Cubic Centimeter.	Estimated Per Cent. Which Species Last Applied formed of Total Numbers in Effluent.	REMARKS.
Feb. 27, . . .	12.00	2	0	-	Applied dose contained 135,000 *B. coli communis* per cubic centimeter.
27, . . .	12.30	28	5,000	99	Not dosed again with bacteria until March 29.
27, . . .	1.00	30	5,400	99	- -
27, . . .	1.30	30	4,580	99	- -
27, . . .	2.00	28	3,840	99	- -
27, . . .	3.00	20	5,670	99	- -

Results of Bacterial Examinations of Effluent from Filter No. 13 — Continued.

DATE — 1892.	Hour.	Rate of Flow. Cubic Centimeters per Minute.	Bacteria per Cubic Centimeter.	Estimated Per Cent. Which Species Last Applied formed of Total Numbers in Effluent.	REMARKS.
Mar. 1, . . .	1.30	30	162	60	- -
2, . . .	1.30	28	324	95	- -
3, . . .	2.14	20	132	85	- -
4, . . .	1.30	28	156	95	- -
5, . . .	12.00	2	248	95	- -
5, . . .	12.30	30	281	95	- -
5, . . .	1.00	32	220	80	- -
5, . . .	1.30	30	234	80	- -
5, . . .	3.00	20	670	70	- -
7, . . .	1.30	30	156	95	- -
10, . . .	2.08	26	420	90	- -
11, . . .	1.30	30	1,932	90	- -
12, . . .	12.30	28	204	90	- -
12, . . .	1.30	28	294	95	- -
12, . . .	2.30	24	324	95	- -
17, . . .	3.03	20	132	75	- -
29, . . .	12.00	4	55	0	Applied dose contained 60,000 *B. prodigiosus* per cubic centimeter.
29, . . .	1.00	34	119	7	- -
29, . . .	2.00	30	5,500	90	- -
29, . . .	3.40	20	6,000	90	- -
31, . . .	2.12	28	300	10	- -
April 1, . . .	1.37	32	290	15	- -
2, . . .	12.00	2	106	60	Applied dose contained 30,000 *B. coli communis* per cubic centimeter.
2, . . .	1.00	34	2,300	90	- -
2, . . .	2.00	32	6,000	90	- -
2, . . .	3.00	24	5,900	90	- -
6, . . .	1.40	32	490	70	- -
7, . . .	2.12	28	438	75	- -
8, . . .	12.00	2	37	0	Applied dose contained 3,130 *B. janthinus* per cubic centimeter.
8, . . .	1.00	34	624	60	- -
8, . . .	2.00	32	942	55	- -
8, . . .	3.00	24	792	60	- -
11, . . .	1.37	26	275	50	- -
12, . . .	12.00	2	40	0	Applied dose contained 1,370 *B. cloacæ* per cubic centimeter.
12, . . .	1.00	36	298	10	- -

Results of Bacterial Examinations of Effluent from Filter No. 13 — Concluded.

DATE — 1892.	Hour.	Rate of Flow. Cubic Centimeters per Minute.	Bacteria per Cubic Centimeter.	Estimated Per Cent. Which Species Last Applied formed of Total Numbers in Effluent.	REMARKS.
April 12, . . .	2.30	26	336	30	– –
12, . . .	3.30	18	302	50	– –
13, . . .	1.30	36	210	–	– –
21, . . .	12.00	2	18	0	Applied dose contained 100,000 *B. cloacæ* per cubic centimeter.
21, . . .	1.00	32	9,100	99	– –
21, . . .	2.05	28	11,500	99	– –
21, . . .	3.00	24	10,000	99	– –
22, . . .	2.30	26	6,600	–	– –
25, . . .	2.05	26	1,500	–	– –
26, . . .	12.00	2	34,300	99	Applied dose contained 200,000 *B. candicans* per cubic centimeter.
26, . . .	1.30	32	23,500	99	– –
26, . . .	2.30	24	26,800	99	– –
26, . . .	3.30	20	33,700	99	– –
28, . . .	2.10	28	1,750	–	– –
May 13, . . .	1.00	38	1,056	–	No bacteria applied with dose.
13, . . .	1.30	34	1,102	–	– –
13, . . .	2.00	30	750	–	– –
13, . . .	3.00	24	702	–	– –
13, . . .	5.00	14	558	–	– –
June 21, . . .	12.00	2	430	0	Applied dose contained 510,000 *B. typhi abdom.* per cubic centimeter.
21, . . .	1.30	32	32,800	99	– –
21, . . .	2.30	26	26,300	99	– –
21, . . .	3.30	20	45,500	99	– –
22, . . .	3.30	22	770	50	– –
Dec. 1, . . .	12.00	2	936	1	Applied dose contained 2,000 *B. prodigiosus* per cubic centimeter.*
1, . . .	12.30	12	856	1	– –
1, . . .	1.00	30	1,075	1	– –
1, . . .	1.30	29	334	3	– –
1, . . .	2.00	29	415	1	No ammonia had been applied since September 26.
1, . . .	2.30	30	252	5	– –
1, . . .	3.00	25	248	6	Nitrogen as nitrate was 0 19 parts per 100,000.
1, . . .	3.30	20	704	4	– –
1, . . .	4.00	18	376	5	– –
1, . . .	4.30	18	802	2	– –
1, . . .	5.00	16	936	4	– –

* These bacteria were applied in 8 per cent. of the amount of bouillon used in previous experiments.

The number of bacteria leaving this filter during the application of the ammonium chloride and sodium carbonate, and for several months after its discontinuance, was much larger than the number of bacteria applied, showing that, in connection with the high, though incomplete, nitrification there was deposited in the filter a food supply favorable for the growth of bacteria; hence we have to conclude from these experiments that a large amount of ammonia may be nitrified in a filter without destroying the bacteria, so long as there remains in the filter an abundant food supply not nitrified.

SOME PHYSICAL PROPERTIES

OF

SANDS AND GRAVELS,

WITH SPECIAL REFERENCE TO THEIR USE IN FILTRATION.

By ALLEN HAZEN,

CHEMIST IN CHARGE OF THE LAWRENCE EXPERIMENT STATION.

SOME PHYSICAL PROPERTIES OF SANDS AND GRAVELS, WITH SPECIAL REFERENCE TO THEIR USE IN FILTRATION.

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Chemist in Charge of Lawrence Experiment Station.

The experiments at the Lawrence Experiment Station under the direction of Hiram F. Mills, C.E., have necessitated many investigations in regard to the physical properties of filtering materials. The following is a brief account of some of the methods of analysis devised in the course of these investigations, together with the more important results obtained.

Method of Analysis.

A knowledge of the sizes of the sand grains forms the basis of many of the computations. This information is obtained by means of mechanical analyses. The sand sample is separated into portions having grains of definite sizes, and from the weight of the several portions the relative quantities of grains of any size can be computed.

Collection of Samples.

In shipping and handling, samples of sands are best kept in their natural moist condition, as there is then no tendency to separation into portions of unequal-sized grains. Under no circumstances should different materials be mixed in the same sample. If the material under examination is not homogeneous, samples of each grade should be taken in separate bottles, with proper notes in regard to location, quantity, etc. Eight-ounce wide-necked bottles are most convenient for sand samples, but with gravels a larger quantity is often required. Duplicate samples for comparison after obtaining the results of analyses are often useful.

Separation into Portions having Grains of Definite Sizes.

Three methods are employed for particles of different sizes,— hand picking for the stones, sieves for the sands and water elu-

triation for the extremely fine particles. Ignition, or determination of albuminoid ammonia, might be added for determining the quantity of organic matter, which, as a matter of convenience, is assumed to consist of particles less than 0.01 millimeter in diameter.

The method of hand picking is ordinarily applied only to particles which remain on a sieve two meshes to an inch. The stones of this size are spread out so that all are in sight, and a definite number of the largest are selected and weighed. The diameter is calculated from the average weight by the method to be described, while the percentage is reckoned from the total weight. Another set of the largest remaining stones is then picked out and weighed as before, and so on until the sample is exhausted. With a little practice the eye enables one to pick out the largest stones quite accurately.

With smaller particles this process becomes too laborious, on account of the large number of particles, and sieves are therefore used instead. The sand for sifting must be entirely free from moisture, and is ordinarily dried in an oven at a temperature somewhat above the boiling point. The quantity taken for analysis should rarely exceed 100–200 grams. The sieves are made from carefully selected brass-wire gauze, having, as nearly as possible, square and even-sized meshes. The frames are of metal, fitting into each other so that several sieves can be used at once without loss of material. It is a great convenience to have a mechanical shaker, which will take a series of sieves and give them a uniform and sufficient shaking in a short time; but without this good results can be obtained by hand shaking. A series which has proved very satisfactory has sieves with approximately 2, 4, 6, 10, 20, 40, 70, 100, 140, and 200 meshes to an inch; but the exact numbers are of no consequence, as the actual sizes of the particles are relied upon, and not the number of meshes to an inch.

It can be easily shown by experiment that when a mixed sand is shaken upon a sieve the smaller particles pass first, and as the shaking is continued larger and larger particles pass, until the limit is reached when almost nothing will pass. The last and largest particles passing are collected and measured, and they represent the separation of that sieve. The size of separation of a sieve bears a tolerably definite relation to the size of the mesh, but the relation is not to be depended upon, owing to the irregularities in the meshes and also to the fact that the finer sieves are woven on a different pattern from the coarser ones, and the particles passing the finer sieves are somewhat larger in proportion to the mesh than is

the case with the coarser sieves. For these reasons the sizes of the sand grains are determined by actual measurements, regardless of the size of the mesh of the sieve.

It has not been found practicable to extend the sieve separations to particles below 0.10 millimeter in diameter (corresponding to a sieve with about 200 meshes to an inch), and for such particles elutriation is used. The portion passing the finest sieve contains the greater part of the organic matter of the sample, with the exception of roots and other large undecomposed matters, and it is usually best to remove this organic matter by ignition at the lowest possible heat before proceeding to the water separations. The loss in weight is regarded as organic matter, and calculated as below 0.01 millimeter in diameter. In case the mineral matter is decomposed by the necessary heat, the ignition must be omitted, and an approximate equivalent can be obtained by multiplying the albuminoid ammonia of the sample by 50.* In this case it is necessary to deduct an equivalent amount from the other fine portions, as otherwise the analyses when expressed in percentages would add up to more than one hundred.

Five grams of the ignited fine particles are put in a beaker 90 millimeters high, and holding about 230 cubic centimeters. The beaker is then nearly filled with distilled water at a temperature of 20° C., and thoroughly mixed by blowing into it air through a glass tube. A larger quantity of sand than 5 grams will not settle uniformly in the quantity of water given, but less can be used if desired. The rapidity of settlement depends upon the temperature of the water, so that it is quite important that no material variation in temperature should occur. The mixed sand and water is allowed to stand for fifteen seconds, when most of the supernatant liquid, carrying with it the greater part of the particles less than 0.08 millimeter, is rapidly decanted into a suitable vessel, and the remaining sand is again mixed with an equal amount of fresh water, which is again poured off after fifteen seconds, carrying with it most of the remaining fine particles. This process is once more repeated, after which the remaining sand is allowed to drain, and is then dried and weighed, and calculated as above 0.08 millimeter in diameter. The finer decanted sand will have sufficiently settled in a few minutes, and the coarser parts at the bottom are washed back into the beaker and treated with water exactly as before, except that one minute interval

* The method of making this determination was given in the *American Chemical Journal*, Vol. 12, p. 427.

is now allowed for settling. The sand remaining is calculated as above 0.04 millimeter, and the portion below 0.04 is estimated by difference, as its direct determination is very tedious, and no more accurate than the estimation by difference when sufficient care is used.

Determination of the Sizes of the Sand Grains.

The sizes of the sand grains can be determined in either of two ways, — from the weight of the particles or from micrometer measurements. For convenience the size of each particle is considered to be the diameter of a sphere of equal volume. When the weight and specific gravity of a particle are known, the diameter can be readily calculated. The volume of a sphere is $\frac{1}{6} \pi d^3$, and is also equal to the weight divided by the specific gravity. With the Lawrence materials the specific gravity is uniformly 2.65 within very narrow limits, and we have $\frac{w}{2.65} = \frac{1}{6} \pi d^3$. Solving for d we obtain the formulæ $d = .9 \sqrt[3]{w}$ when d is the diameter of a particle in millimeters and w its weight in milligrams. As the average weight of particles, when not too small, can be determined with precision, this method is very accurate, and altogether the most satisfactory for particles above 0.10 millimeter; that is, for all sieve separations. For the finer particles the method is inapplicable, on account of the vast number of particles to be counted in the smallest portion which can be accurately weighed, and in these cases the sizes are determined by micrometer measurements. As the sand grains are not spherical or even regular in shape, considerable care is required to ascertain the true mean diameter. The most accurate method is to measure the long diameter and the middle diameter at right angles to it, as seen by a microscope. The short diameter is obtained by a micrometer screw, focusing first upon the glass upon which the particle rests and then upon the highest point to be found. The mean diameter is then the cube root of the product of the three observed diameters. The middle diameter is usually about equal to the mean diameter, and can generally be used for it, avoiding the troublesome measurement of the short diameters.

The sizes of the separations of the sieves are always determined from the very last sand which passes through in the course of an analysis, and the results so obtained are quite accurate. With the elutriations average samples are inspected, and estimates made of the range in size of particles in each portion. Some stray particles both above and below the normal sizes are usually present, and even with the greatest care the result is only an approximation to the truth;

still, a series of results made in strictly the same way should be thoroughly satisfactory, notwithstanding possible moderate errors in the absolute sizes.

Calculation of Results.

When a material has been separated into portions, each of which is accurately weighed and the range in the sizes of grains in each portion determined, the weight of the particles finer than each size of separation can be calculated, and with enough properly selected separations the results can be plotted in the form of a diagram, and measurements of the curve taken for intermediate points with a fair degree of accuracy. This curve of results may be drawn upon a uniform scale using the actual figures of sizes and of per cents. by weight, or the logarithms of the figures may be used in one or both directions. The method of plotting is not of vital importance, and the method for any set of materials which gives the most easily and accurately drawn curves is to be preferred. In the diagram published last year the logarithmic scale was used in one direction, but in many instances the logarithmic scale can be used to advantage in both directions. With this method it has been found that the curve is often almost a straight line through the lower and most important section, and very accurate results are obtained even with a smaller number of separations.

Examples of Calculation of Results.

Following are examples of representative analyses, showing the method of calculation used with the different methods of separation employed with various materials.

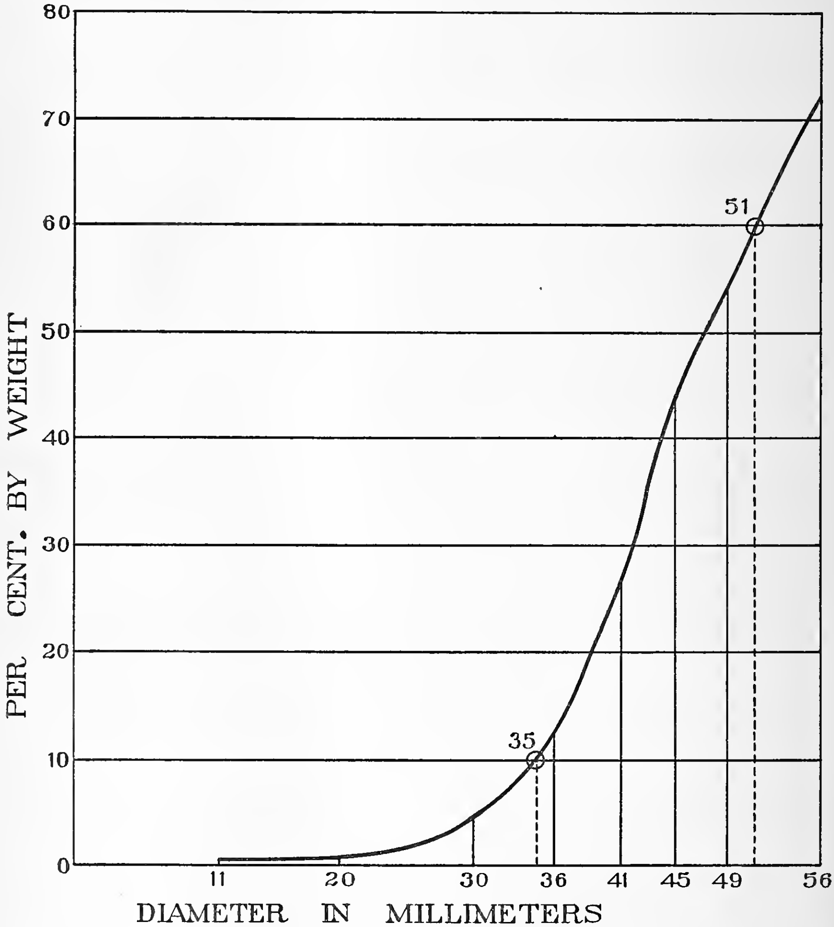
I. Analysis of a Gravel by Hand Picking, 11,870 Grams Taken for Analysis.

Number of Stones in Portion. (Largest Selected Stones.)	Total Weight of Portion. — Grams.	Average Weight of Stones. — Milligrams.	Estimated Weight of Smallest Stones. — Milligrams.	Corresponding Size. — Millimeters.	Total Weight of Stones Smaller than this Size.	Per Cent. of Total Weight Smaller than this Size.
. . . .	–	–	–	–	11,870	100.
10, ...	3,320	332,000	250,000	56.	8,550	72.
10, ...	1,930	193,000	165,000	49.	6,620	56.
10, ...	1,380	138,000	124,000	45.	5,240	44.
20, ...	2,200	110,000	93,000	41.	3,040	26.
20, ...	1,520	76,000	64,000	36.	1,520	13.
20, ...	1,000	50,000	36,000	30.	520	4.4
20, ...	460	23,000	10,000	20.	60	.5
10, ...	40	4,000	2,000	11.	20	.2
Dust, ...	20	–	–	–	–	–

The weight of the smallest stones in a portion given in the fourth column is estimated in general as about half-way between the average weight of all the stones in that portion and the average weight of the stones in the next finer portion.

The final results are shown by the figures in full-faced type in the last and third from the last columns. By plotting these figures (*Figure I.*) we find that 10 per cent. of the stones are less than 35 millimeters in diameter, and 60 per cent. are less than 51 millimeters. The uniformity coefficient, as described below, is the ratios of these numbers, or 1.46, while the "effective size" is 35 millimeters.

Figure I.



II. Analysis of a Sand by Means of Sieves.

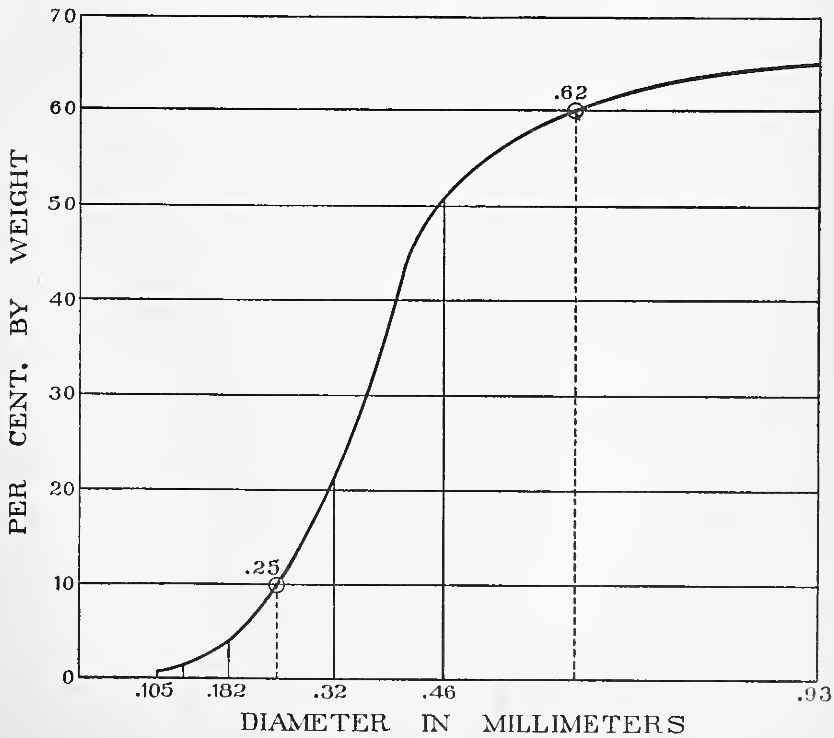
A portion of the sample was dried in a porcelain dish in an air bath. Weight dry, 110.9 grams. It was put into a series of sieves in a mechanical shaker, and given one hundred turns (equal to about seven hundred single shakes). The sieves were then taken apart, and the portion passing the finest sieve weighed. After noting the

weight, the sand remaining on the finest sieve but passing all the coarser sieves was added to the first, and again weighed, this process being repeated until all the sample was upon the scale, weighing 110.7 grams, showing a loss by handling of only 0.2 grams. The figures were as follows: —

Sieve Marked	Size of Separation of this Sieve. — Millimeters.	Quantity of Sand Passing. — Grams.	Per Cent. of Total Weight.	Sieve Marked	Size of Separation of this Sieve. — Millimeters.	Quantity of Sand Passing. — Grams.	Per Cent. of Total Weight.
190, ...	**.105**	.5	**.5**	40, ...	**.46**	56.7	**51.2**
140, ...	**.135**	1.3	**1.2**	20, ...	**.93**	89.1	**80.5**
100, ...	**.182**	4.1	**3.7**	10, ...	**2.04**	104.6	**94.3**
60, ...	**.320**	23.2	**21.0**	6, ...	**3.90**	110.7	**100.0**

Plotting the figures in heavy-faced type we find from the curve (*Figure II.*) that 10 and 60 per cent. respectively are finer than .25 and .62 millimeter, and we have for effective size, as described above, .25, and for uniformity coefficient 2.5.

Figure II.



III. Analysis of a Fine Material with Elutriation.

The entire sample, 74 grams, was taken for analysis. The sieves used were not the same as those in the previous analysis, and instead of mixing the various portions on the scale they were separately weighed. The siftings were as follows: —

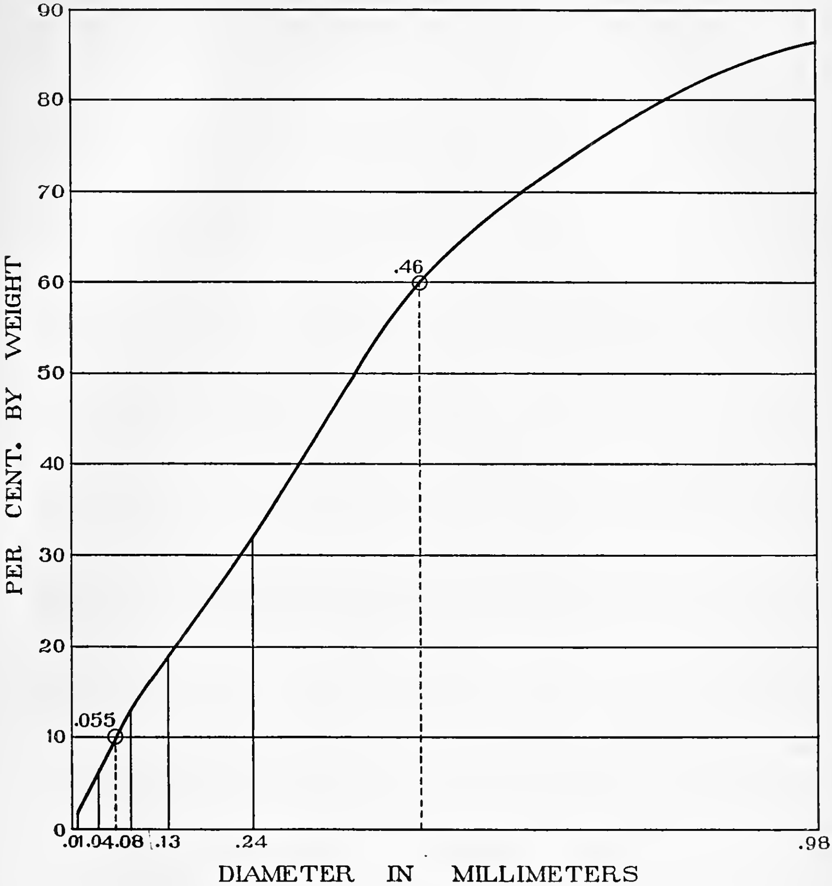
Remaining on Sieve	10, above 2.2	millimeters,	. .	1.5 grams.
" "	20, " .98	"	. .	7.0 "
" "	40, " .46	"	. .	22.0 "
" "	70, " .24	"	. .	20.2 "
" "	140, " .13	"	. .	9.2 "
Passing sieve, .	140, below .13	"	. .	14.1 "

The 14.1 grams passing the 140 sieve were thoroughly mixed, and one-third, 4.7 grams, taken for analysis. After ignition, just below a red heat in a radiator, the weight was diminished by 0.47 gram. The portion above .08 millimeter and between .04 and .08 millimeter, separated as described above, weighed respectively 1.27 and 1.71 grams, and the portion below .04 millimeter was estimated by difference (4.7 — (0.47 + 1.27 + 1.71)) to be 1.25 grams. Multiplying these quantities by 3, we obtain the corresponding quantities for the entire sample, and the calculation of quantities finer than the various sizes can be made, as follows: —

Size of Grain.	Weight. — Grams.	Size of Largest Particles. — Millimeters.	Weight of all the Finer Particles. — Grams.	Per Cent. by Weight of all Finer Particles.
Above 2.20, ...	1.50	-	74.00	**100**
.98-2.20, ...	7.00	**2.20**	72.50	**98**
.46- .98, ...	22.00	**.98**	65.50	**89**
.24- .46, ...	20.20	**.46**	43.50	**60**
.13- .24, ...	9.20	**.24**	23.30	**32**
.08- .13, ...	3.81	**.13**	14.10	**19**
.04- .08, ...	5.13	**.08**	10.29	**14**
.01- .04, ...	3.75	**.04**	5.16	**7**
Loss on ignition (assumed to be less than .01 millimeters), . . .	1.41	**.01**	1.41	**1.9**

By plotting the heavy-faced figures, we find (*Figure III.*) that 10 and 60 per cent. are respectively finer than .055 and .46 millimeter, and we have effective size .055 millimeter and uniformity coefficient 8.

Figure III.



The Effective Size.

As a provisional basis which best agrees with the known facts, the size of grain where the curve cuts the ten per cent. line is considered to be the "effective size" of the material. This size is such that 10 per cent. of the material is of smaller grains, and 90 per cent. is of larger grains than the size given. The results obtained at Lawrence indicate that the finer 10 per cent. have as much influence upon the action of a material in filtration as the coarser 90 per cent. This is explained by the fact that in a mixed material, containing particles of various sizes, the water is forced to go around the larger particles and through the finer portions which occupy the intervening spaces, and so it is this finest portion which mainly determines the frictional

resistance, the capillary attraction, and, in fact, the action of the sand in almost every way.

Another important point in regard to a material is its degree of uniformity; whether the particles are mainly of the same size, or whether there is a great range in their diameters. This is conveniently shown by the "uniformity coefficient," a term used to designate the ratio of the size of grain which has 60 per cent. of the sample finer than itself to the size which has 10 per cent. finer than itself. These sizes are taken directly from the curve of results.

It is not probable that the above data regarding a sand include all the important points to be known, or that further study will not modify or change the method of calculation; but, in the absence of better methods, their use allows extremely valuable approximate calculations, which would otherwise be almost impossible.

Determination of Open Space and Water by Volume.

As it is often necessary to make determinations of open space and water in sands, a few notes in regard to the most suitable methods will be given.

The specific gravity of the solid particles is obtained by putting a weighed quantity of the thoroughly dry material into a narrow-necked graduated flask of distilled water, taking great care that no air bubbles are inclosed, and weighing the displaced water. Very accurate results may be obtained in this way. The specific gravity of the material as a whole is obtained by weighing a known volume packed as it is actually used, or as nearly so as possible. As the material is usually moist, it should either be dried before weighing or else a moisture determination made and a correction applied. The open space is invariably obtained by dividing the specific gravity of the material as a whole when dry by the specific gravity of the solid particles, and deducting the quotient from 1. The results obtained by measuring the quantity of water which can be put into a given volume when introduced from below are invariably too low, because the water is drawn ahead by capillarity, and air bubbles are enclosed and remain, often causing serious errors. A rough estimate of the open space can be made from the uniformity coefficient. Sharp-grained materials having uniformity coefficients below 2, have nearly 45 per cent. open space as ordinarily packed; and sands having coefficients below 3, as they occur in the banks or artificially settled in water, will usually have 40 per cent. open space. With more mixed materials the closeness of packing

increases, until, with a uniformity coefficient of 6 to 8, only 30 per cent. open space is obtained, and with extremely high coefficients almost no open space is left. With round-grained water-worn sands the open space has been observed to be from 2 to 5 per cent. less than for corresponding sharp-grained sands.

The quantity of water contained in sand is obtained by drying a weighed portion in the usual way. The volume of the water is reckoned by the formula $V = sp.\ gr.\ \frac{M}{100-M}$ when *sp. gr.* is the specific gravity of the material as a whole when dry and M is the per cent. of moisture by weight. The difference between this figure and the open space is, in general, the air space.

Capillarity.

To determine the capillarity of a sand it is so placed that it is drained at a defined level, great care being taken to secure a compact packing free from stratification. Water is put freely upon it, and after a definite time, usually twenty-four or forty-eight hours, sand samples are taken at various levels, and water determinations made as described above. The results plotted give a curve of "water capacity." *

The height to which water will be held to such an extent as to prevent the circulation of air can be roughly estimated by the formula $h = \frac{1.5}{d^2}$ when h is the height in millimeters and d the effective size of sand grain. The data from which the constant given above as 1.5 was calculated are very inadequate, and consequently the formula may require modification with more extended observations.

The height to which water is held by capillarity is independent of temperature.

Determination of Frictional Resistance.

To determine the frictional resistance of a material, a cylinder of galvanized iron of convenient size is filled with the material packed under conditions as far as possible like those under which it is to be used. For water filtration the material is put loosely in position and settled to a compact condition by introducing water from below. Stratification must be carefully avoided. Water is then passed through at definite rates, keeping the material covered with an excess of water, and regulating the rate of flow by the faucet at the bottom. The accompanying diagram (*Figure IV.*) represents a section of the apparatus (not drawn to scale). The loss of head

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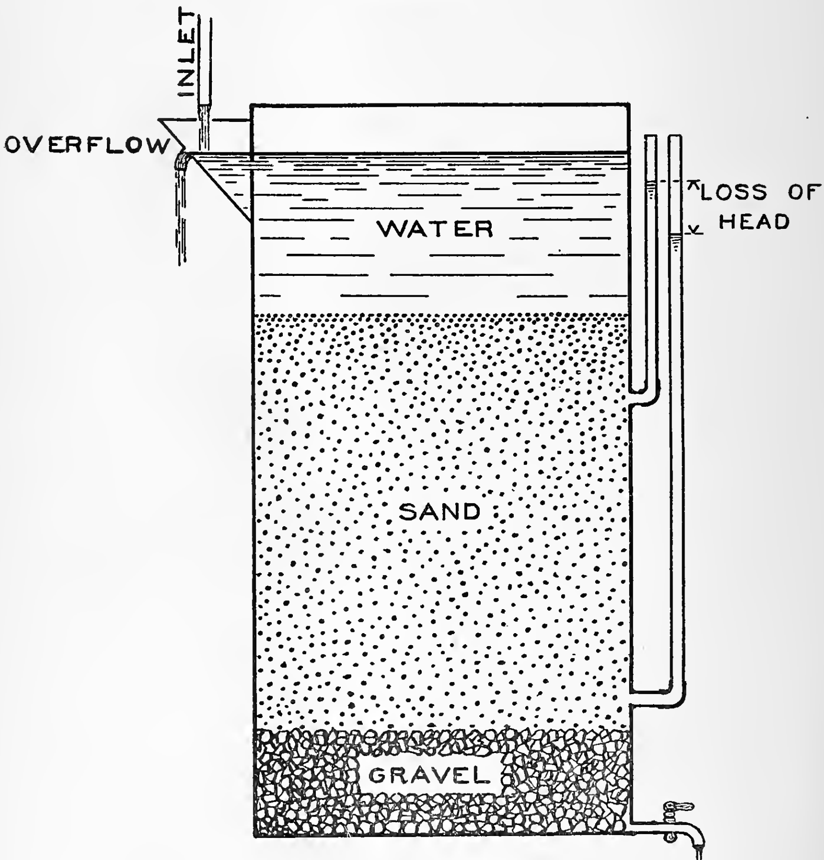
* The results of a number of such experiments were given in the annual report for 1891, page 432.

between two points at a definite distance apart and both well within the material under examination is observed in glass tubes attached to pet cocks covered with fine wire gauze to keep back the material. By proceeding in this way we eliminate the loss of head in the surface layer of sand, which is always much greater than for corresponding material below the surface, and is better studied by itself. The friction when the experiment is first started is always high, because many air bubbles are retained in the sand; but if water not entirely saturated with air is applied continuously for some days the air bubbles are absorbed and constant normal results are obtained.

Figure IV.



FRICTION OF WATER IN SANDS AND GRAVELS.

The frictional resistance of sand to water within certain limits of size of grain and rate of flow varies directly as the rate and as the

depth of sand. This is given by Piefke * as Darcy's law. I have found that the friction also varies with the temperature, being twice as great at the freezing point as at summer heat both for coarse and fine sands, and also that with different sands the resistance varies inversely as the square of the effective size of the sand grain. It probably varies also somewhat with the uniformity coefficient, but no satisfactory data are at hand upon that point.

Putting the available data in the shape of a formula, we have

$$V = c\, d^2 \frac{h}{l} (.70 + .03t),$$

where

- V is the velocity of the water in meters daily in a solid column of the same area as that of the sand,
- c is a constant factor which present experiments indicate to be approximately 1,000,
- d is the effective size of sand grain,
- h is the loss of head,
- l is the thickness of sand through which water passes,
- t is the temperature on the centigrade scale ($\frac{t\,\text{Fahr.} + 10}{60}$ may be substituted for the last term, if desired).

The data at hand only justify the application of this formula to sands having a uniformity coefficient below 5, and effective size of grain 0.10 to 3.00 millimeters.

The quantity of water which will filter through a sand when its pores are completely filled with water and in the entire absence of clogging, with an active head equal to the depth of sand, and at a temperature of 10° Centigrade, forms an extremely convenient basis for calculation, and for convenience is called the "maximum rate," as it is approximately equal to the greatest quantity of water which can be made to pass the sand under ordinary working conditions. Thus a sand with effective size, .20 millimeter, has a maximum rate of 40 meters per day; with effective size .30 millimeter, the maximum rate is 90 meters per day, etc.

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* Zeitschrift für Hygiene, Vol. VII., p. 115.

TABLE *showing Rate at which Water will pass through Different Sands, with Various Heads, at a Temperature of 10° Centigrade.*

$\frac{h}{l}$	Effective Size in Millimeters, 10 Per Cent. Finer than—						
	0.10	**0.20**	**0.30**	**0.40**	**0.50**	**1.00**	**3.00**
	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.
.001,	.01	.04	.09	.16	.25	1.	9.
.005,	.05	.20	.45	.80	1.25	5.	45.
.010,	.10	.40	.90	1.60	2.50	10.	90.
.050,	.50	2.00	4.50	8.00	12.50	50.	-
.100,	1.00	4.	9.	16.	25.	100.	-
.500,	5.	20.	45.	80.	125.	-	-
1.000,	10.	40.	90.	160.	-	-	-
2.000,	20.	80.	180.	320.	-	-	-

The effect of variation in the temperature is shown by the following table :

Relative Quantities of Water passing at Different Temperatures.

Degrees, Centigrade,	0°	5°	10°	15°	20°	25°	30°
Degrees, Fahrenheit,	32°	41°	50°	59°	68°	77°	86°
Quantity,	.70	.85	1.00	1.15	1.30	1.45	1.60

For gravels with effective sizes above 3 millimeters the friction varies in such a way as to make the application of a general formula very difficult. As the size increases beyond this point, the velocity with a given head does not increase as rapidly as the square of the effective size; and with coarse gravels the velocity varies as the square root of the head instead of directly with the head as in sands. The influence of temperature also becomes less marked with the coarse gravels.

The available data for materials above 3 millimeters, which are far less complete than could be desired, have been obtained entirely from screened gravels with uniformity coefficients from 1.4 to 2.0, and at a temperature of 10° C., or a little above. The results obtained were plotted, making a diagram from which the table given below has been prepared. The figures given in the table must be taken as provisional, and for use only until more extended results are obtained.

TABLE *showing Rate at which Water will pass through Different Gravels with Various Heads.*

$\frac{h}{l}$	Effective Size in Millimeters, 10 Per Cent. Finer Than —									
	3	5	8	10	15	20	25	30	35	40
	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.	Meters per Day.
.0005, . . .	3.5	10	20	30	50	80	110	150	200	250
.001, . . .	7	21	41	58	100	148	205	275	370	450
.002, . . .	14	40	78	110	190	275	370	480	590	710
.004, . . .	27	77	150	208	350	480	610	740	870	1,000
.006, . . .	41	112	207	275	450	620	780	930	1,090	1,240
.008, . . .	54	142	252	340	530	720	900	1,090	1,270	1,450
.010, . . .	67	173	300	385	610	830	1,030	1,220	1,410	-
.015, . . .	98	238	378	480	760	1,030	1,260	1,480	-	-
.020, . . .	127	300	467	580	890	1,180	1,470	-	-	-
.030, . . .	185	400	615	750	1,110	1,450	-	-	-	-
.050, . . .	280	560	885	1,060	1,490	-	-	-	-	-
.100, . . .	495	930	1,310	1,550	-	-	-	-	-	-

In making calculations in regard to underdrains for either sewage or water filters, or in regard to the movements of ground waters, there should be no perceptible clogging of porous materials free from stratification by a clear ground water, and the formulæ given can be used with only a moderate factor of safety to cover possible errors of sampling, analysis, and errors in the formulæ themselves. In estimating the actual capacity of a filter, so many other conditions come in — the presence of air bubbles and especially the increased friction in the upper layers — that it is impossible to calculate the practicable rate of flow by formulæ, and we can only safely rely upon actual results from known materials.

The analyses of the materials used at Lawrence have been given in previous reports of the Board in connection with the results obtained from them, and also in this volume, pages 424 and 454. The following table contains the result of analyses of some other materials, which may be of general interest : —

Mechanical Analyses of Sands.

	Effective Size 10 Per Cent. Finer Than —	Uniformity Coefficient.
	Millimeters.	
Filter Tank No. 1, Lawrence, Mass.,	.48	2.4
Filter Tank No. 9, Lawrence, Mass.,	.18	2.0
Filter Tank No. 2, Lawrence, Mass.,	.08	2.0
Sewage filters, Gardner, Mass.,	.10-.24	6-14
Sewage filters, Marlborough, Mass.,	.12	3.4
Sewage filters, South Framingham, Mass.,	.35-.42	4-5
Water filter, Lawrence, Mass.,	.25-.30	2.5- 4.5
Water filter, Birmingham, Eng.,	.27	1.8
Water filter, Southwalk & Vauxhall Co., London, Eng.,	.29	2.0
Water filter, Poughkeepsie, N. Y.,	.25-.35	1.8- 1.9

The data already collected clearly show that a well-selected material is essential to successful filtration; and, with the method of examination and calculation now proposed, we can decide with confidence many otherwise indefinite points, and thus avoid unnecessary expense and unsatisfactory results from the use of unsuitable or poorly arranged materials.

SEWAGE DISPOSAL

OF

CITIES AND TOWNS IN MASSACHUSETTS

BY INTERMITTENT FILTRATION.

SEWAGE DISPOSAL OF CITIES AND TOWNS IN MASSACHUSETTS BY INTERMITTENT FILTRATION.

The first plant for the disposal of town sewage by intermittent filtration in Massachusetts was constructed at Lenox in 1876. A system for the disposal of the sewage of a portion of the town of Amherst, partly by filtration and partly by irrigation, was constructed about 1881, and a small system for the disposal of sewage by intermittent filtration was introduced at Medfield in 1886. Since the last date the towns of Framingham, Marlborough, Gardner and Westborough have constructed and are now operating works for the disposal of sewage by intermittent filtration, and a new disposal field has been constructed and is in use at Lenox. The city of Brockton (population in 1890, 27,294) is at present constructing works of this kind, but they are not yet in operation.

In order to study the results obtained by the practical use of this system of sewage disposal, the State Board of Health has caused many analyses of sewage and of effluent from the filter-beds at Framingham, Marlborough and Gardner to be made, and the results of these analyses up to July, 1893, together with a sufficient description of the works at these three places to render intelligible the conditions under which the results were obtained, will be found in the following pages.

As an aid in comparing the results, it may be said that the conditions at Framingham are very favorable in regard to the area of available and prepared land in proportion to the amount of sewage to be treated, the porosity of the land, and the depth to ground water. Owing to the height of the land above an adjacent brook, and the porosity of the material, only a limited amount of underdrainage was found to be necessary, and most of the effluent, instead of coming out at the underdrains, passes for a long distance through the ground, and appears in the form of springs at the edge of the

low land near the brook. That portion of the effluent which comes out through the underdrains is very well purified, particularly in summer, while that which passes a long distance through the ground and comes out at the springs is completely purified.

At Marlborough the sand is somewhat finer than at Framingham, although porous and well adapted to sewage purification. In this case it was found necessary to underdrain the land, and the underdrains are placed in parallel lines fifty feet apart and about six feet beneath the surface. The effluent is well purified, but the beds have been operated in such a manner that the sewage frequently ponds upon them, and under such circumstances it passes so quickly to the underdrains that it is not at all times as thoroughly purified as it would be if smaller quantities were evenly distributed over the beds.

At Gardner there was only one place near the town where porous material could be reached by gravity, and it was thought necessary to adopt this location, although the beds had to be almost wholly artificial, and their total area was necessarily quite small. The material is coarse sand, and the beds are very thoroughly underdrained by lines of tile laid twenty feet apart and from four to five feet beneath the surface. Although the area of the beds is limited, it has been found feasible to dispose of all of the sewage by filtration in summer and obtain a good effluent, if the sediment is frequently raked in or removed from the surface of the beds; but in the cold weather of winter, when this sediment cannot be removed, the beds have become partially clogged and some of the sewage has run over into the brook.

The relative porosity of the filter-beds at the three places, as indicated by mechanical analyses of samples of sand, has already been given on page 419 of this report.

Sewage Disposal at Framingham.

The town of Framingham (population in 1890, 9,239) contains three villages, of which South Framingham is by far the most populous, and up to the present time is the only village sewered. The sewage of the women's prison, located in the town of Sherborn, just beyond the Framingham line, is also taken care of by this system. The sewerage system was put in operation near the end of the year

1889, and at the end of 1892 four hundred and fifty-one dwelling-houses and thirty-nine business blocks, stores, factories, etc., were connected with the sewers.

The village of South Framingham is situated on a generally level tract of sandy land, lying within the drainage area from which the water supply of the city of Boston is drawn; and, in order that there might be no danger of polluting the water supply of the city by the effluent from a sewage field, the city of Boston offered to defray a part of the expense of disposing of the sewage at a point beyond the limits of this drainage area.

As in this case it was necessary both to pump and to purify the sewage, all storm water was excluded from the sewers, and special care was taken to prevent the entrance of ground water, both by making tight joints and by the construction of a continuous system of underdrains beneath the principal sewers to collect and carry off the ground water. The main underdrain discharges by gravity into a brook, and the character of the water discharged by it can be seen by reference to a table of analyses on page 131 of this report.* The water flows freely into the underdrain, and the ground water level has been permanently lowered. There is little doubt that if the underdrain had been omitted, a large part of the water which enters it would have entered the sewers, and thereby have increased largely the amount of sewage to be pumped and purified, notwithstanding the care taken to secure tight joints. Even with the precautions taken, the amount of sewage flowing during a season of high rainfall is fully three times the ordinary flow. The average amount of sewage pumped and purified in 1892 was 177,000 gallons per day.

The sewage after arriving at the pumping station in a 24 x 36 inch brick sewer, first passes through a screen and gate chamber, then into a pair of receiving reservoirs, each 110.5 feet long by 30 feet wide, having a total capacity of 431,000 gallons, which retain the night sewage and make it possible to do all the pumping in the daytime. From the pumping station the sewage is forced through a cast-iron main 12 inches in diameter and 9,740 feet in length, to

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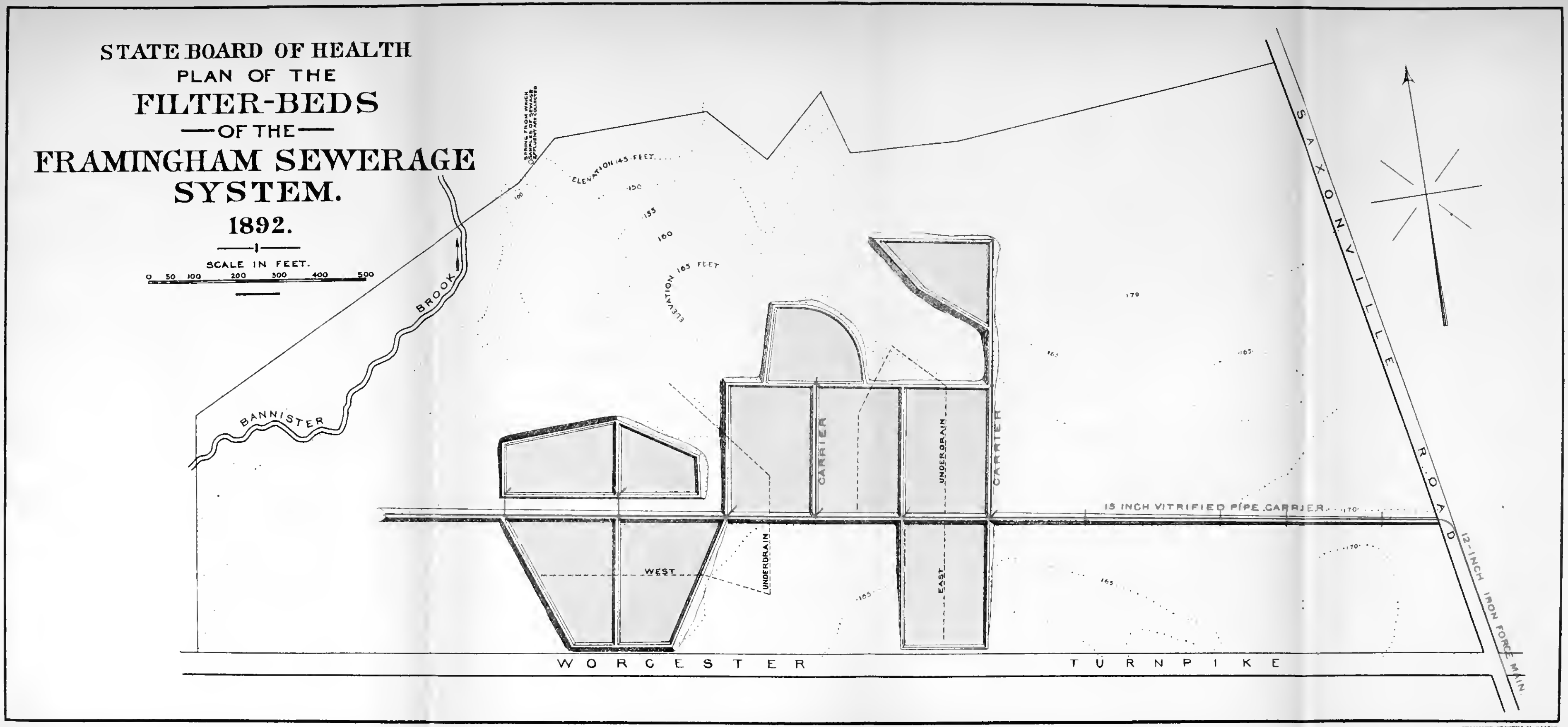
* Analyses of water from this underdrain are also given in the annual reports of the Board for 1890 and 1891, pages 149 and 126 respectively. The first sample analyzed was collected before any sewage had been admitted to the sewers, and the character of the water has not changed materially since the sewage was admitted.

the boundary of the filtration area, where it connects with a main carrier consisting of a vitrified clay pipe covered with an embankment and extending longitudinally through the area.

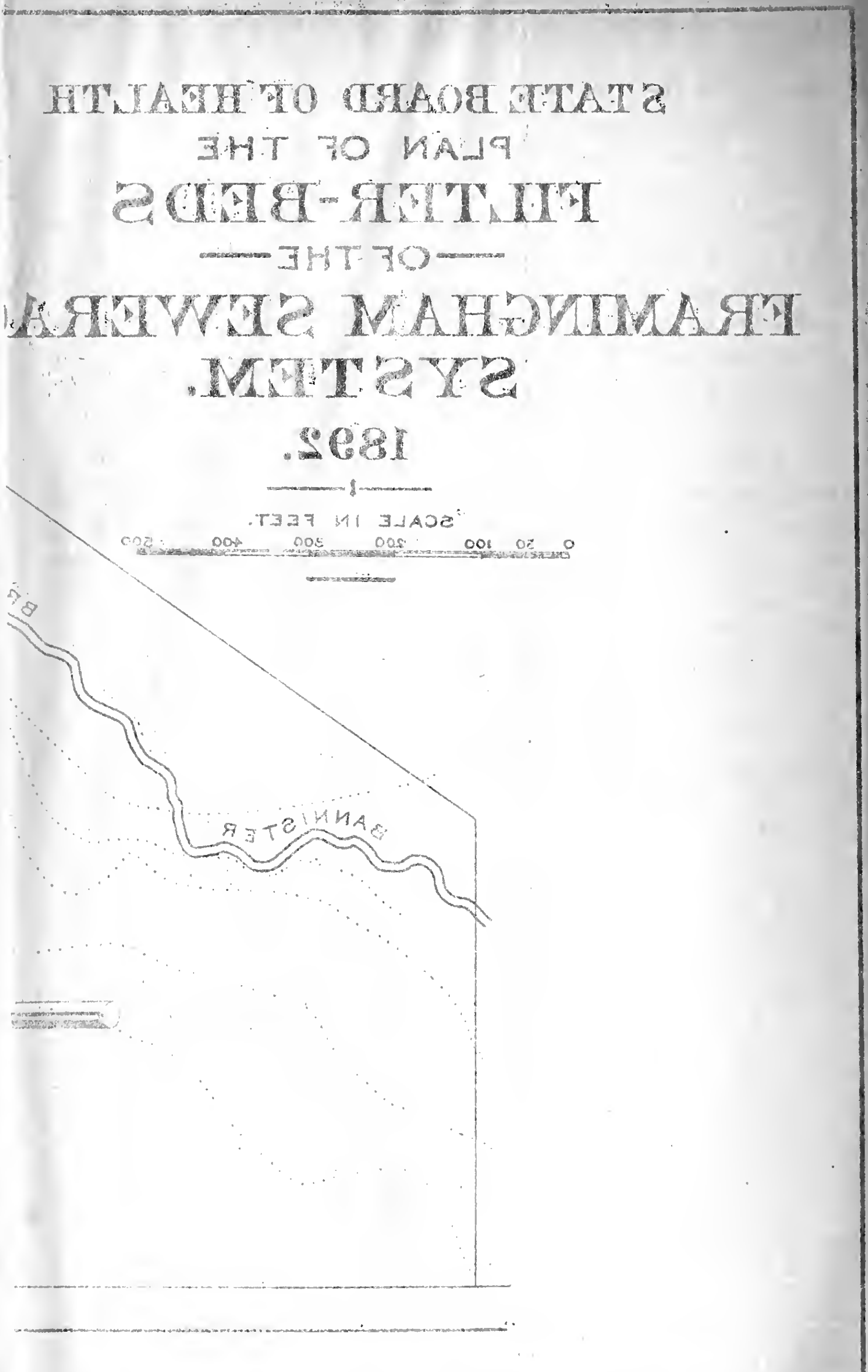
This area, which is shown in detail on the accompanying plan, is located in the town of Natick, just beyond the Framingham line, and contains about seventy acres, much of which is nearly level, and about twenty feet above Bannister Brook, which flows along its north-westerly border. At two places narrow ravines run up from this brook a considerable distance into the flat land. Of the tract owned by the town, about twelve acres have been specially prepared for intermittent filtration by being divided into ten beds of convenient size, by the removal of as much loam as could be used in the embankments around the beds, and by levelling the surface. Six of these beds are underdrained to a limited extent by means of a single line of six-inch pipe laid six feet below the surface through the middle of each bed. These underdrains discharge into the two ravines already mentioned, but, as already stated in the introductory portion of this article, they collect but a small portion of the effluent, and the amount which they do discharge flows upon the porous ground at so high a level that it again filters into the ground and receives a second filtration before reaching the brook.

Outlets from the main carrier and its branches are so arranged that sewage can be turned upon each bed at one, two or three points, generally at the corners of the bed. These outlets as a rule discharge into open carriers formed of earth at the sides of the embankments around the beds, and from these open carriers the sewage flows upon the beds through numerous openings made with a shovel in their sides. These openings are of a temporary character, and can be enlarged or reduced in size, or closed entirely, as may be found desirable by the attendant whose duty it is to see that the sewage is evenly distributed over the beds. Under ordinary circumstances the pumps are operated but once a day, and then only for five or six hours. This insures a period of rest between the applications of sewage, even when the sewage is applied to the same bed on consecutive days.

In addition to the prepared beds, nearly the entire area has been cleared of its growth of bushes and trees, and provision has been made for applying the sewage to some portions of it without further preparation of the surface. A portion of the sewage has been



HELIOTYPE PRINTING CO. BOSTON


STATE BOARD OF HEALTH
PLAN OF THE
FILTER-BEDS
OF THE
FRAMINGHAM SEWERA[GE]
SYSTEM.
1892.
SCALE IN FEET.
0 50 100 200 300 400 500
BANNISTER

disposed of in this way upon the ground in its natural state in a very satisfactory manner.

The sewage is ordinary town sewage, discolored and somewhat modified in character at times by a considerable amount of spent dyes discharged into the sewers from the straw goods factories in the town. No attempt is made to remove the sludge, but some of the coarser matters are removed by the screens, and some sludge is undoubtedly deposited in the receiving basins, although none has yet been removed from them except by pumping it with the sewage to the disposal field. The sewage is somewhat dilute during seasons of heavy rainfall, as has already been indicated. The water supply of Framingham is taken from the ground, and its winter temperature is about 49° F. The sewage, which has a temperature of from 48° to 50°, is consequently much warmer than it would be if the water supply was taken from a surface water source. This is a great advantage in the winter disposal of the sewage at this place.

The results obtained at Framingham in the disposal of sewage have been very satisfactory indeed, as all of the sewage has been filtered without causing offence in the neighborhood, and without injuring the small brook into which the effluent flows. In the tables which follow will be found the analyses of samples of the sewage and of effluent collected from different places at the sewage field, some from the spring near the edge of the low land, which has already been referred to, and some from the underdrains. For convenience the following typical determinations are presented to show the extent to which the free and albuminoid ammonia are removed and the nitrogen in them converted into nitrates by filtration : —

	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrates.
Sewage,	1.6400	0.3800	0.0100
Sewage effluent from underdrains, in winter,	0.2800	0.0110	0.3300
Sewage effluent from underdrains, in summer,	0.0750	0.0060	1.0000
Sewage effluent from spring,	0.0000	0.0020	0.3700

In judging the effect which the effluent may have upon the stream into which it flows, the analyses of samples from the spring

should be used, because the water discharged from the underdrains filters into the ground again, and is probably as pure as the spring water when it reaches the brook after this second filtration. It is instructive, however, as a matter of general interest, to note the difference in the effluent collected at these two places.

The water from the underdrains as dipped up and examined at the sewage field is perfectly clear, colorless and odorless, and furnishes no indication of being other than good spring water; when, however, it is subjected to the severer tests of the laboratory, and the water is shaken in a half-filled gallon bottle, after it has stood for a day, a musty and even an offensive odor is sometimes noticed. The analyses show that ninety-eight per cent. of the organic matter, as represented by the albuminoid ammonia, is removed from the sewage when the effluent leaves the underdrains, and they also show a reduction of ninety-one per cent. in the amount of free ammonia.

The effluent collected from the spring has always been free from odor even under the severe tests of the laboratory, and it is as free from organic matter, free ammonia and bacteria as most natural spring waters. It contains, of course, the mineral matters of the sewage, which cannot be removed by filtration, and the mineral matters which result from the oxidation of the organic substances.* In the last annual report of the Board (pages 356–357) are contained the analyses of spring waters offered for sale in Massachusetts. It is fair to say that the effluent from the spring at the sewage field varies so little both in mineral, organic and bacterial constituents from some of these spring waters from populous districts, that neither the chemist nor the bacteriologist could distinguish between unmarked samples of the two.

The fact that the winter of 1892–93 was an exceptionally cold one has already been referred to on page 419 of this report. The mean temperature of the air at Framingham, during the months of December, January and February for the past ten years, is given in the following table: —

* The character and quantity of these mineral matters may be seen by referring to page 351 of this report, where a comparison is made between the normal spring water of this region and the water from this spring, which is about one-half sewage effluent.

[Degrees Fahrenheit.]

	1883-84.	1884-85.	1885-86.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	1891-92.	1892-93.	Average for Ten Years.
December, ...	26.6	31.1	30.8	26.2	29.6	32.6	36.8	24.1	37.8	26.6	30.2
January, ...	22.2	26.2	24.0	21.8	18.1	32.6	32.3	28.3	25.7	16.4	24.8
February, ...	32.6	18.1	25.5	27.7	25.8	24.2	32.6	31.1	27.6	24.4	27.0
Average, ...	27.1	25.1	26.8	25.2	24.5	29.8	33.9	27.8	30.4	22.5	27.3

It will be seen from this table that January, 1893, was the coldest January during these ten years, and that December and February stood third in order of coldness during this period. Taking the three months together, the temperature averaged 2° lower than in the corresponding months of any other winter, and 4.8° lower than the average temperature for these months for the ten years. The mean minimum temperature for December, 1892, was 18°; for January, 1893, 6.3°; and for February, 1893, 13.4°.

The test furnished by such an extremely cold winter was made somewhat more severe by the fact that there was no snow upon the ground in December, which permitted the ground to become thoroughly frozen, there was very little in January, and these conditions were followed by an extremely heavy snowfall (8.15 inches of melted snow) in February. Under these conditions the sewage was disposed of without difficulty. It was found, however, that the sewage could be distributed more easily upon beds where corn had been grown the previous summer, and the hills had not been disturbed, than upon level beds. The reason for this was, that in the former case the ice and snow formed a covering, resting upon the corn hills, under which the sewage could flow in the depressions between the hills without coming in contact with the ice, while in the latter case the covering of ice and snow rested directly upon the sewage, and it occasionally happened in the very cold weather that the last of the sewage was cooled to the freezing point before it had all disappeared, with the result that the ice froze solidly to the surface of the beds, and the frost penetrated the nearly saturated sand.

It was found in the middle of the winter that beds which had not been in use for several months and which were consequently frozen

to a considerable depth would permit the sewage to pass so freely that an increased flow of effluent in the underdrains was observed six or seven hours after the application of sewage began; and that by applying the sewage to these beds in comparatively large doses, all of the frost would soon disappear.

During the first two years the sewage beds were used for the fil-

Chemical Examination of

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1891.										
1	7204	Apr. 11	Apr. 13	Decided.	Heavy.	-	-	-	-	-	-	-
2	7502	June 30	July 1	Decided, milky.	V. heavy, dark.	0.20	-	20.90*	-	-	5.40*	-
3	7769	Aug. 10	Aug. 11	Decided, opaque.	Cons., floc.	0.70	40.00	35.70	4.30	10.00	8.00	2.00
		1892.										
4	8776	Apr. 20	Apr. 21	Decided.	Heavy.	1.20	-	-	-	-	-	-
5	9376	Sept. 15	Sept. 16	Decided.	Cons., gray.	0.30	47.00	41.90	5.10	13.50	11.20	2.30
		1893.										
6	9900	Jan. 18	Jan. 19	Thick, purple.	Heavy, black.	-	66.90	57.60	9.30	31.50	24.30	7.20
7	10002	Feb. 13	Feb. 14	Decided.	Cons., gray.	0.50	41.10	34.80	6.30	11.50	8.50	3.00
8	10051	Feb. 27	Feb. 28	Decided.	Cons., gray.	0.30	29.70	24.50	5.20	11.80	8.10	3.70
9	10111	Mar. 13	Mar. 14	Decided.	Cons., gray.	0.70	40.20	31.00	9.20	16.40	9.10	7.30
10	10163	Mar. 27	Mar. 28	Decided.	Cons., gray.	0.15	25.10	20.90	4.20	7.90	4.10	3.80
11	10228	Apr. 11	Apr. 12	Thick.	Cons., dark.	1.50	77.70	32.60	45.10	46.70	8.90	37.80
12	10299	Apr. 24	Apr. 25	Decided.	Heavy, gray.	-	33.80	27.30	6.50	11.40	6.30	5.10
13	10360	May 8	May 9	Decided.	Cons., dark.	0.08	55.50	19.20	36.30	36.10	3.90	32.20
14	10426	May 22	May 23	Decided.	Heavy, gray.	0.40	72.50	26.00	46.50	49.50	6.50	43.00
15	10507	June 12	June 13	Decided.	Heavy, gray.	0.04	45.70	29.60	16.10	22.00	8.00	14.00
16	10554	June 23	June 24	Thick.	Heavy, brown.	0.40	265.80	37.00	228.80	193.20	15.10	178.10
17	10625	July 10	July 11	Decided, opaque.	Cons., dark.	0.40	35.80	30.40	5.40	13.50	9.70	3.80
18	10702	July 26	July 27	Decided.	Cons., dark.	-	37.80	32.20	5.60	15.80	12.30	3.50
19	Av..	....	....	....	....	0.49	60.97	32.04	28.93	32.72	9.60	23.12

* These determinations are not included in the averages.

tration of sewage only; but in 1892 the experiment was tried of raising crops of corn, cabbages, beets, squashes and rye-grass, and the results were so satisfactory that a larger area was planted in 1893. It is now proposed to prepare a still larger area for the cultivation of crops, although the present filter-beds are amply able to take care of the sewage.

Sewage from Framingham.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.		Bacteria per Cubic Centimeter.	
	Albuminoid.										
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		Unfiltered.	Filtered.		
.4400	.1070	.0420	.0650	3.41	.0150	.1000	7.3	-	-	-	1
1.4000	.4200	.0800	.3400	2.58	.0070	.0002	-	-	-	-	2
2.8800	.2980	.1110	.1870	5.63	.0050	.0000	5.4	-	-	660,800	3
1.0880	.4070	.2790	.1280	4.00	.0120	.0000	-	-	-	1,000,000	4
1.6000	.2980	.1800	.1180	4.35	.0070	.0000	5.7	.0900	.0880	-	5
3.3280	.6100	.4260	.1840	6.73	.0050	.0000	4.2	.2950	.1520	-	6
.8960	.3100	.2060	.1040	4.30	.0050	.0800	7.7	.0500	.0460	-	7
1.7600	.3840	.2220	.1620	4.30	.0070	.0000	6.0	.0550	.0430	-	8
1.1600	.3120	.1680	.1440	3.90	.1000	.0500	7.0	.0900	.0460	-	9
.9600	.2460	.0940	.1520	3.22	.1000	.0400	7.0	.0550	.0350	-	10
2.5600	.0530	.0306	.0224	5.00	.0250	.0020	6.6	.0800	.0300	-	11
.8320	.2880	.1880	.1000	3.48	.0150	.0010	6.0	.0430	.0370	-	12
.4640	.4520	.0500	.4020	3.15	.0050	.0480	8.9	.0870	.0130	-	13
.9600	.3400	.1720	.1680	3.58	.0070	.0025	8.1	.0650	.0120	-	14
1.8400	.3340	.1800	.1540	5.47	.0000	.0010	8.7	.0330	.0230	-	15
1.9200	1.4300	.2220	1.2080	5.26	.0070	.0001	8.6	.5600	.0750	-	16
2.8000	.3380	.2220	.1160	5.84	.0050	.0010	6.0	.0400	.0200	-	17
2.6880	.3040	.2280	.0760	6.10	.0070	.0005	6.1	.0380	.0350	-	18
1.6431	.3851	.1723	.2128	4.46	.0186	.0181	6.8	.1129	.0468	830,400	19

Odor, offensive. —— The sewage is collected as it flows out upon the filter-beds.

Chemical Examination of Effluent from the East

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1891.						
1	7205	Apr. 11	Apr. 13	None.	None.	0.00	Faintly musty.	None.
2	7503	June 30	July 1	None.	Very slight.	0.00	None.	Very faintly mouldy.
		1892.						
3	8779	Apr. 20	Apr. 21	None.	None.	0.00	None.	None.
4	8812	Apr. 27	Apr. 28	None.	None.	0.00	Distinctly musty.	None.
5	8855	May 4	May 5	None.	None.	0.00	Faintly musty.	Very faint.
		1893.						
6	10113	Mar. 13	Mar. 14	Distinct.	Considerable.	0.10	Offensive.	Offensive.
7	10165	Mar. 27	Mar. 28	Slight.	Slight, sand.	0.04	Offensive.	Offensive.
8	10230	Apr. 11	Apr. 12	Very slight.	Very slight.	0.02	Faintly musty.	Faintly musty and disagr'ble.
9	10301	Apr. 24	Apr. 25	Very slight.	Very slight.	0.00	Offensive.	Offensive.
10	10362	May 8	May 9	None.	Slight.	0.03	Faintly musty.	Distinctly musty.
11	10428	May 22	May 23	None.	None.	0.02	Offensive.	Decidedly musty.
12	10508	June 12	June 13	Slight.	Slight, white.	0.04	Offensive.	Offensive.
13	10556	June 23	June 24	Very slight.	None.	0.10	Distinctly musty.	Decidedly musty.
14	10627	July 10	July 11	None.	None.	0.02	Distinctly musty.	Distinctly musty.
15	10704	July 26	July 27	None.	Very slight.	0.00	Decidedly musty.	Distinctly musty.
16	Av.	....	....	....	....	0.02	....	....

The samples were collected from

Chemical Examination of Effluent from the West

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1891.						
1	7206	Apr. 11	Apr. 13	None.	Very slight.	0.00	Faintly musty.	None.
2	7504	June 30	July 1	None.	Very slight.	0.00	None.	Very faintly mouldy.
		1892.						
3	8778	Apr. 20	Apr. 21	None.	Very slight.	0.00	None.	None.
4	8813	Apr. 27	Apr. 28	None.	Slight.	0.01	Decidedly musty.	Distinctly musty.
5	8856	May 4	May 5	None.	Very slight.	0.02	Faintly musty.	Decidedly musty.
6	8885	May 11	May 12	None.	Very slight.	0.00	None.	Distinctly musty.
7	9377	Sept. 15	Sept. 16	Very slight.	Slight.	0.00	None.	Faintly mouldy.

Underdrain at the Framingham Filter-beds.

[Parts per 100,000]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	Bacteria per Cubic Centimeter.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
-	.0152	.0018	1.80	.4000	.0021	2.6	-	-	1
19.80	.0160	.0044	3.00	1.0000	.0005	4.6	-	271	2
-	.0336	.0024	2.40	.2750	.0001	3.2	-	50	3
-	.0416	.0030	2.47	.3250	.0002	-	-	25	4
-	.0300	.0022	2.20	.3500	.0005	-	-	20	5
13.10	.4400	.0100	2.56	.0800	.0250	4.2	.0000	-	6
22.10	.4400	.0180	3.35	.3750	.0024	6.3	.0000	-	7
14.90	.0920	.0100	3.40	.5000	.0030	3.5	.0080	-	8
22.80	.3400	.0100	3.60	.9000	.0050	5.3	.0200	-	9
18.70	.1600	.0080	3.38	.8000	.0050	3.8	.0000	-	10
31.70	.5600	.0240	3.26	1.8750	.0050	8.3	.0000	-	11
31.20	.2400	.0110	4.11	2.3750	.0050	6.3	.0150	-	12
19.20	.1520	.0070	3.20	.8000	.0080	4.1	.0070	-	13
24.60	.1600	.0110	3.41	1.4000	.0090	6.0	.0000	-	14
25.80	.1640	.0050	3.92	1.2000	.0070	6.0	.0350	-	15
22.17	.1923	.0085	3.07	.8437	.0052	4.9	.0085	-	16

the underdrain at its outlet.

Underdrain at the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	Bacteria per Cubic Centimeter.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
-	.0760	.0030	1.80	.2200	.0005	3.2	-	-	1
19.10	.0800	.0100	3.00	.9500	.0002	4.6	-	47	2
-	.0114	.0018	2.85	.8000	.0008	4.0	-	200	3
-	.0496	.0092	3.60	.9500	.0010	-	-	100	4
-	.0092	.0032	2.37	.5500	.0005	-	-	150	5
-	.0064	.0020	2.67	.8000	.0003	-	-	15	6
16.20	.0016	.0048	3.07	.4500	.0020	3.0	.0140	-	7

Chemical Examination of Effluent from the West Under-

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.						
1	9901	Jan. 18	Jan. 19	Distinct, milky.	Slight.	0.30	Disagreeable.	Offensive.
2	10004	Feb. 13	Feb. 14	None.	Slight.	0.02	Decidedly musty.	Offensive.
3	10052	Feb. 27	Feb. 28	None.	Cons. sand.	0.03	Distinctly musty.	Decidedly musty.
4	10112	Mar. 13	Mar. 14	Slight.	Considerable.	0.08	Decidedly musty.	Decidedly musty.
5	10164	Mar. 27	Mar. 28	None.	Cons. sand.	0.00	Faintly musty.	Decidedly musty.
6	10229	Apr. 11	Apr. 12	Slight.	Slight.	0.03	Offensive.	Decidedly offensive.
7	10300	Apr. 24	Apr. 25	Slight.	Heavy, earthy.	0.00	Distinctly musty.	Decidedly musty.
8	10361	May 8	May 9	Very slight.	Very slight.	0.03	Distinctly musty.	Faintly musty.
9	10427	May 22	May 23	None.	None.	0.01	Distinct.	Distinctly musty.
10	10509	June 12	June 13	None.	None.	0.02	Distinctly musty.	Distinctly mouldy.
11	10585	June 23	June 24	Very slight.	Slight.	0.08	Faintly musty.	Distinctly musty.
12	10626	July 10	July 11	Very slight.	Slight.	0.01	Distinctly musty.	Distinctly musty.
13	10703	July 26	July 27	None.	Slight.	0.03	Distinctly musty.	Decidedly musty.
14	Av.	....	....	....	....	0.03	....	....

The samples were collected from

Chemical Examination of Water from a Spring near Bannister

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1891.						
1	7505	June 30	July 1	None.	None.	0.00	None.	Very faint or none.
2	7770	Aug. 10	Aug. 11	Very slight.	Cons., earthy	0.00	None.	None.
3	7860	Aug. 25	Aug. 26	None.	None.	0.00	None.	None.
		1892.						
4	8777	Apr. 20	Apr. 21	None.	None.	0.00	None.	None.
5	8816	Apr. 27	Apr. 28	None.	Slight.	0.00	Decidedly musty.	None.
6	8853	May 4	May 5	None.	Very slight.	0.00	None.	None.
7	8884	May 11	May 12	None.	None.	0.00	Very faint or none.	None.
8	9375	Sept. 15	Sept. 16	None.	Very slight.	0.00	None.	None.

drain at the Framingham Filter-beds — Concluded.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	Bacteria per Cubic Centimeter.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
30.60	.3800	.0250	5.00	.0090	.0080	5.0	.0020	-	1
17.10	.0258	.0080	3.32	.4000	.0005	4.4	.0060	-	2
18.50	.1400	.0070	3.80	.5200	.0000	4.4	.0060	-	3
9.50	.0800	.0040	1.80	.1500	.0007	2.2	.0000	-	4
14.20	.0800	.0110	2.60	.4500	.0030	3.5	.0000	-	5
11.10	.4400	.0150	3.90	.4500	.0040	5.3	.0050	-	6
20.20	.1400	.0030	3.24	1.0000	.0080	4.6	.0360	-	7
18.00	.1200	.0040	3.04	.7500	.0030	4.2	.0000	-	8
20.00	.0720	.0040	2.76	.9000	.0050	4.8	.0100	-	9
27.90	.0800	.0060	3.93	1.3750	.0050	5.7	.0250	-	10
20.90	.0600	.0070	3.12	1.0000	.0060	4.7	.0100	-	11
29.70	.0800	.0130	3.80	1.6000	.0080	7.6	.0100	-	12
29.90	.0720	.0100	4.18	1.6000	.0050	6.7	.0200	-	13
20.19	.1002	.0075	3.19	.7464	.0031	4.6	.0103	-	14

the underdrain at its outlet.

Brook, which receives Effluent from the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	Bacteria per Cubic Centimeter.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
7.40	.0000	.0000	1.20	.1250	.0000	1.8	-	30	1
7.20	.0000	.0034	1.22	.1100	.0000	1.7	-	11	2
7.10	.0000	.0012	1.30	.1250	.0000	2.1	-	5	3
-	.0000	.0044	2.18	.3000	.0000	2.6	-	30	4
-	.0000	.0070	2.04	.3000	.0000	-	-	25	5
-	.0000	.0032	2.16	.3250	.0000	-	-	6	6
-	.0000	.0010	2.28	.3600	.0000	-	-	10	7
10.65	.0000	.0002	2.13	.3000	.0001	3.2	.0100	-	8

Chemical Examination of Water from a Spring near Bannister Brook,

[Parts per 100,000.]

		Date of		Appearance.			Odor.	
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Cold.	Hot.
		1893.						
1	10003	Feb. 13	Feb. 14	None.	Slight.	0.00	Very faint or none.	None.
2	10053	Feb. 27	Feb. 28	None.	Cons., dark.	0.00	None.	None.
3	10114	Mar. 13	Mar. 14	None.	None.	0.00	None.	None.
4	10166	Mar. 27	Mar. 28	None.	Cons., dark.	0.00	None.	None.
5	10231	Apr. 11	Apr. 12	None.	Slight, earthy.	0.00	None.	None.
6	10302	Apr. 24	Apr. 25	None.	Slight, earthy.	0.00	None.	None.
7	10363	May 8	May 9	None.	Slight.	0.00	None.	None.
8	10429	May 22	May 23	None.	None.	0.00	None.	None.
9	10510	June 12	June 13	None.	Slight.	0.01	Very faint or none.	Very faint or none.
10	10557	June 23	June 24	None.	None.	0.00	None.	None.
11	10628	July 10	July 11	None.	None.	0.00	None.	None.
12	10705	July 26	July 27	Very slight.	Slight, sandy.	0.00	None.	None.
13	Av.	....	....	....	....	0.00	....	....

Chemical Examination of Water from Bannister Brook below the Framingham Filter-beds.

[Parts per 100,000.]

	Date of		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as		
									Albuminoid.						
Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
	1892.														
9378	Sept. 15	Sept. 16	V. slight.	Slight.	1.10	8.70	4.25	.0000	.0456	.0316	.0140	.66	.0500	.0003	2.1

Odor, vegetable.—— The water was collected at the first road crossing below the sewage field.

Sewage Disposal at Marlborough.

The sewerage system of the city of Marlborough (population in 1890, 13,805) was completed late in 1891, but only about fifty connections were made with the sewers before the end of that year. By June, 1892, there were about three hundred and fifty connections, and on Jan. 1, 1893, about six hundred. At the present time all of the larger places, such as hotels, factories, etc., and a large number of houses, are connected. The total length of sewers laid up to the end of 1892 was 21.03 miles.

which Receives Effluent from the Framingham Filter-beds — Concluded.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	Bacteria per Cubic Centimeter.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
11.40	.0004	.0020	2.32	.3500	.0000	3.9	.0000	-	1
11.95	.0000	.0016	2.43	.3750	.0000	3.5	.0040	-	2
11.05	.0000	.0002	2.80	.3750	.0000	3.2	.0000	-	3
12.40	.0000	.0004	2.60	.5000	.0000	3.6	.0000	-	4
11.25	.0000	.0016	2.56	.5250	.0000	3.4	.0025	-	5
11.65	.0000	.0000	2.47	.3500	.0000	3.8	.0100	-	6
12.75	.0000	.0012	2.61	.5500	.0000	3.4	.0015	-	7
12.50	.0000	.0038	2.79	.5000	.0000	3.1	.0085	-	8
16.10	.0000	.0030	3.34	.5500	.0000	3.0	.0025	-	9
15.10	.0000	.0010	3.18	.6000	.0000	3.4	.0000	-	10
13.40	.0000	.0024	3.18	.4000	.0000	3.2	.0050	-	11
14.20	.0000	.0038	2.82	.4500	.0000	2.8	.0100	-	12
11.63	.0000	.0021	2.38	.3735	.0000	3.0	.0042	17	13

The city is situated on a hill, and its natural drainage is into both the Sudbury and Assabet River valleys. By far the greater part of the city, however, naturally drains toward the Sudbury River, from which the city of Boston takes its water supply. The city of Boston, therefore, had a direct interest in having the sewage removed beyond the limits of its watershed, and agreed to pay a certain sum of money to defray the extra cost of disposing of the sewage in this way. The so-called separate system was adopted at this place, and the sewage flows by gravity to the sewage field. No underdrains were laid beneath the sewers, and a large amount of ground water enters them at some seasons of the year.

As the sewage arrives at the disposal field it passes through separating tanks and screens before passing into the distributing pipes. The tanks are built in duplicate, to facilitate cleaning, and, including the portions where the screens are situated, are each about 25 feet long, $6\frac{1}{2}$ feet wide and 6 feet deep. The screens are of wire and have a one-inch mesh. The elevation of the tanks above the sandy land is such that it was feasible to prepare beds upon which the sludge deposited in the tanks could be turned by gravity.

The total area of the tract bought by the city is 62.7 acres.

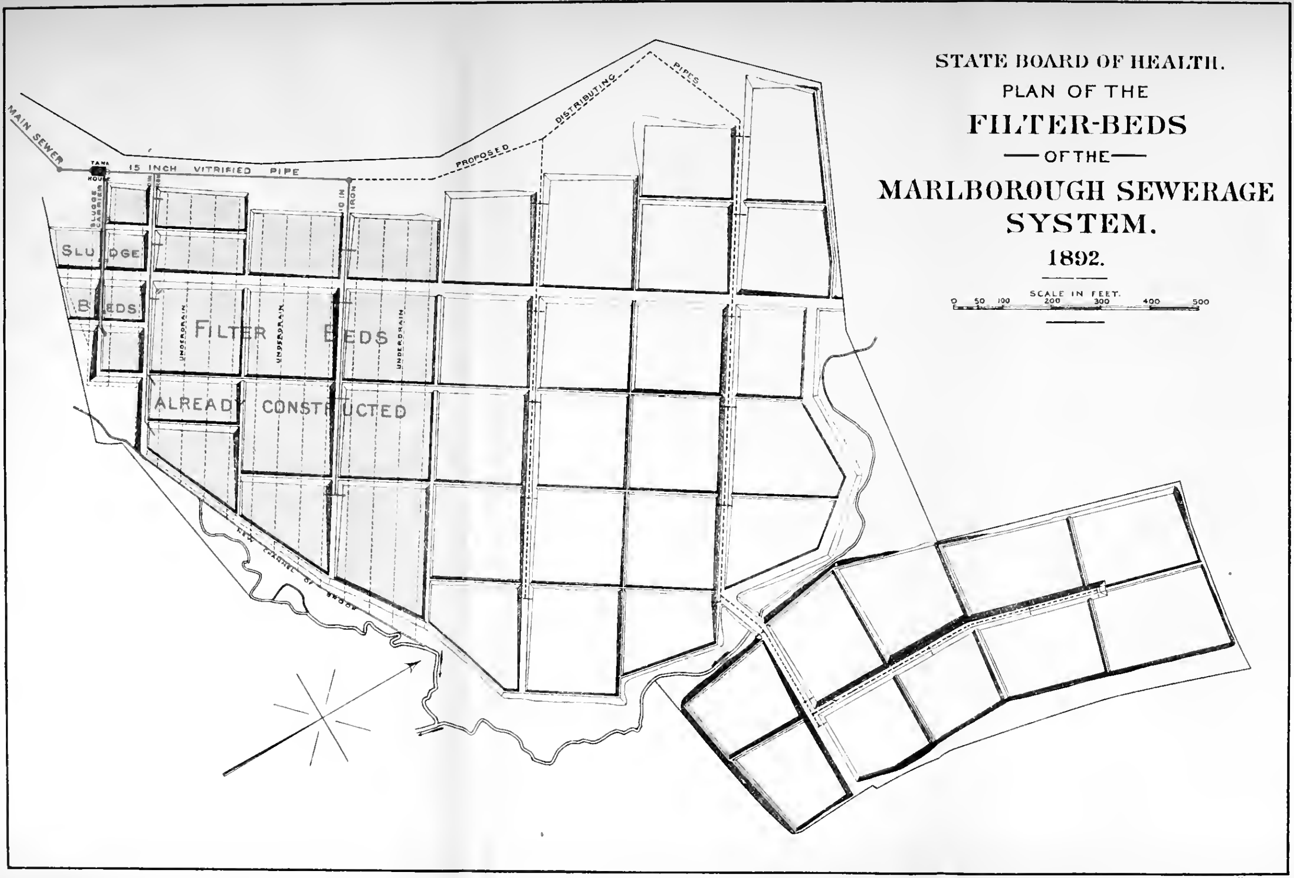
Upon this tract forty-four beds for the filtration of sewage and six smaller beds for the disposal of sludge, covering with their dividing embankments and slopes a total area of 36.8 acres, have been laid out, as shown upon the accompanying plan. Up to the present time only the sludge beds, with a total area of 1.7 acres, and thirteen of the sewage beds, with a total area of 9.6 acres, have been prepared for use.

The material is for the most part a somewhat fine porous sand, the surface of which has a moderate slope toward a small brook, and is from seven to twenty-two feet above it. The beds are thoroughly underdrained by means of parallel lines of four-inch pipes laid with open joints, fifty feet apart, about six feet beneath the surface. All of these drains discharge into the brook before mentioned.

The filter-beds were prepared for use by the removal of very nearly all of the loam, and the levelling of the surface of each at such an elevation as would permit its construction with the movement of a minimum amount of material. Sewage passes from the separating tanks through a main carrier consisting of a fifteen-inch vitrified pipe laid with but a slight grade along the side of the hill above the filter-beds. From this carrier the sewage passes through branch pipes of cast iron laid beneath the embankments separating the beds, and is discharged upon the beds through short branches controlled by gates.

The sewage is ordinary city sewage, varying in strength with the amount of ground water which enters the sewers. On the whole, it is somewhat stronger than that at Framingham. The principal industry in the city is the manufacture of boots and shoes, and the waste matters from the factories which enter the sewers may modify the character of the sewage to some extent. A portion of the suspended matters of the sewage is deposited in the separating tanks, which are cleaned out by allowing their contents to flow upon the sludge beds about twice a month; and the remainder of these matters, which are carried across the tank so quickly by the current of sewage that they do not have time to deposit, are discharged upon the sewage beds with the sewage.

The amount of sewage is not definitely known. On May 12, 1892, when there were a comparatively few connections with the sewers, a measurement was made, and the flow was found to be at the rate of 330,000 gallons per day; and on May 25, 1892, after heavy rains, the rate of flow was 790,000 gallons per day. These amounts must have been almost wholly ground water. The amount of water consumed in Marlborough in 1891 averaged 364,000 gallons per day, and in 1892 425,000 gallons. It is probable that the average daily



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flow of sewage is now as great if not greater than the water consumption, although there is a large proportion of the population of the city which is not yet connected with the sewers.

The results obtained at Marlborough have on the whole been satisfactory, as the sewage has been purified to the extent of removing ninety-five and one-half per cent. of the organic matter, as represented by the albuminoid ammonia; and it has been shown that it is feasible to purify the sewage in this way without causing offence in the neighborhood. There has been, however, at times a strong odor from the sludge beds when the sludge was allowed to remain upon them a long time; and even when the sludge tanks are emptied twice a month upon the beds and the sludge is removed as soon as it dries, there is considerable odor while it remains on the beds. This in the present case does very little harm, as the beds are a long distance from any road and from habitations, but it could be avoided by the more frequent removal of the sludge from the tanks and the use of a deodorizer at such times. Another cause of odor at the beds has been the leakage of sewage from one or two gates, thereby producing continuous instead of intermittent filtration, and causing small pools of putrefying sewage to stand near the gates. Aside from what has been mentioned, the sewage beds are practically free from odor. The purification is not as thorough as at Framingham, as has already been indicated, and a higher degree of purification can undoubtedly be obtained by applying smaller doses of sewage, provided they are distributed uniformly over the surface of the beds. As at present arranged the beds are level, and the sewage is discharged upon each of them at only one point, so that if only a moderate dose of sewage is applied it filters through the portions of the bed near the inlet without reaching more distant portions. In order to utilize the whole area of each bed, large doses are frequently applied, which causes such rapid filtration that the sewage does not have time to become thoroughly purified before reaching the underdrains. A change in the works, by which sewage could be discharged upon the beds at more than one point and distributed by earth carriers, as at Framingham, together with a slight slope of the surface of the beds from the carriers to the more distant parts, would permit the application of smaller doses of sewage, and would undoubtedly produce an effluent of greater purity.

After the sewage has been applied for a time to the beds at Marlborough a scum is formed upon the surface, which is not found upon the beds at Framingham. This as it dries rests loosely upon the

sand, and yet has sufficient thickness and strength so that·it can readily be raked off of the beds and removed.

The beds were operated during the very severe winter of 1892-93, and all of the sewage was filtered through them excepting for a few days, when it was run upon some of the adjacent land. The sewage at this place is colder than at Framingham, its winter temperature being from 39° to 42° F. One or two of the smaller beds farthest

Chemical Examination of

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1892.										
1	8689	Mar. 30	Mar. 31	Distinct.	Cons., gray.	0.05	20.20	19.60	0.60	5.50	5.00	0.50
2	8934	May 25	May 26	Distinct, milky.	Cons.	0.02	24.50	23.70	0.80	8.10	8.00	0.10
3	9041	June 28	June 29	Decided.	Heavy, black.	0.50	62.00	33.40	28.60	21.80	8.00	13.80
4	9042	June 28	June 29	Decided.	Heavy, black.	0.70	58.80	30.60	28.20	20.40	6.20	14.20
5	9169	July 27	July 28	Thick.	Heavy, brown.	0.70	67.90	40.00	27.90	29.50	13.40	16.10
6	9300	Aug. 24	Aug. 25	Decided.	Heavy, dark.	0.80	72.00	47.40	24.60	26.00	13.20	12.80
7	9466	Sept. 28	Sept. 29	Decided, thick.	V. heavy, dark.	0.70	62.60	39.60	23.00	28.50	13.60	14.90
8	9565	Oct. 25	Oct. 26	Decided.	Heavy, brown.	-	68.70	43.90	24.80	35.40	16.10	19.30
9	9735	Nov. 28	Nov. 29	Thick.	V. heavy.	0.80	80.70	40.60	40.10	43.40	13.50	29.90
10	9817	Dec. 20	Dec. 21	Thick.	Heavy, dirty.	0.70	47.20	34.90	12.30	19.40	10.10	9.30
		1893.										
11	9944	Jan. 26	Jan. 27	Decided, milky.	Heavy, dirty.	0.30	30.90	23.40	7.50	10.50	4.50	6.00
12	10023	Feb. 15	Feb. 16	Thick, dirty.	Heavy.	0.80	56.50	32.80	23.70	28.60	10.80	17.80
13	10054	Feb. 27	Feb. 28	Thick.	Heavy, gray.	0.60	91.10	47.40	43.70	58.30	21.20	37.10
14	10118	Mar. 14	Mar. 15	Thick.	Heavy, gray.	0.40	43.70	22.80	20.90	14.60	9.00	5.60
15	10182	Mar. 28	Mar. 29	Decided, milky.	Cons., dark.	0.20	28.70	25.10	3.60	9.70	7.30	2.40
16	10238	Apr. 11	Apr. 12	Decided, milky.	Heavy, black.	0.30	30.20	22.00	8.20	9.40	2.80	6.60
17	10327	Apr. 26	Apr. 28	Decided	Heavy, gray.	0.45	30.90	22.50	8.40	11.20	5.00	6.20
18	10381	May 10	May 11	Decided, milky.	Heavy, white.	0.40	29.50	22.00	7.50	8.30	5.90	2.40
19	10447	May 24	May 26	Decided, milky.	Heavy, dirty.	0.40	32.00	24.40	7.60	11.30	5.00	6.30
20	10519	June 12	June 15	Thick.	Heavy.	0.70	85.30	37.30	48.00	48.50	15.00	33.50
21	10572	June 28	June 29	Decided, black.	Heavy, black.	-	56.20	37.80	18.40	24.70	11.40	13.30
22	10637	July 10	July 11	Decided.	Cons., dark.	0.40	32.00	26.60	5.40	8.30	5.40	2.90
23	10710	July 26	July 28	Thick.	Heavy, black.	0.90	52.80	32.70	20.10	24.30	10.70	13.60
24	Av..	....	....	....	....	0.51	50.63	31.76	18.87	21.99	9.61	12.38

Odor, offensive.—— The samples were collected from the separating tanks, and represent

from the brook were frozen solidly, and on the other beds the ice froze to the ground at points distant from the sewage inlets, though the ground remained unfrozen near these inlets. Probably one-half of the area of the beds was rendered inoperative at the time when the accumulation of frost was greatest. At this place, as at Framingham, it was found that certain beds which were ridged disposed of the sewage more readily in winter than the flat beds.

Sewage from Marlborough.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.		
	Albuminoid.									
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		Unfiltered.	Filtered.	
.1600	.0250	.0100	.0150	3.22	.7000	.0040	6.6	-	-	1
.0720	.0140	.0050	.0090	3.17	.5000	.0120	7.4	-	-	2
1.9200	.5000	.2000	.3000	6.82	.0050	.0000	7.3	-	-	3
1.6000	.5080	.2100	.2980	6.77	.0030	.0000	7.4	-	-	4
2.0000	.8100	.3360	.4740	7.73	.0100	.0000	-	-	-	5
3.2640	.5840	.1960	.3880	12.10	.0050	.0001	7.9	-	-	6
5.7600	.8460	.3760	.4700	7.80	.0000	.0000	8.1	.1800	.1200	7
2.7200	.8200	.4460	.3740	7.50	.0070	.0000	7.6	.1740	.1500	8
1.6000	.9900	.4560	.5340	6.36	.0050	.0000	9.4	.6500	.1680	9
2.4000	.5900	.3080	.2820	7.20	.0180	.0300	6.8	.1550	.0800	10
1.7600	.0462	.0196	.0266	5.00	.1100	.0200	7.3	.0860	.0380	11
2.2400	.6340	.2840	.3500	7.20	.3250	.0200	8.0	.3400	.0450	12
2.0000	1.0540	.5180	.5360	7.16	.0500	.0200	5.4	.2650	.0600	13
1.3600	.2440	.1140	.1300	3.80	.2250	.0360	5.4	.5900	.1540	14
.8000	.2160	.1060	.1100	4.40	.3500	.0400	7.1	.0780	.0250	15
.9600	.1420	.1220	.0200	3.62	.3500	.0500	7.1	.0630	.0240	16
1.2800	.3640	.1240	.2400	4.35	.0070	.1900	6.7	.0670	.0160	17
.9600	.2240	.0740	.1500	3.56	.2500	.0960	6.7	.0450	.0150	18
1.1200	.2600	.1200	.1400	4.80	.0050	.0020	6.6	.0550	.0220	19
2.8800	.6460	.2360	.4100	6.77	.0070	.0010	7.4	.3800	.0950	20
1.8400	.7300	.2840	.4460	6.60	.0050	.0002	7.7	.1600	.0450	21
.9600	.2080	.1500	.0580	5.73	.0070	.0010	8.0	.1700	.1000	22
3.2400	.4760	.1880	.2880	7.25	.0050	.0010	6.1	.1000	.0400	23
1.8650	.4753	.2123	.2630	6.04	.1282	.0228	7.2	.2093	.0704	24

the sewage after a portion of the suspended matter had been separated from it.

Chemical Examination of Effluent from the

[Parts per 100,000.]

		Date of		Appearance.			Odor.	
	Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Cold.	Hot.
		1892.						
1	8687	Mar. 30	Mar. 31	Very slight.	Cons. sand.	0.00	Very faintly mouldy.	Very faintly mouldy.
2	8688	Mar. 30	Mar. 31	Very slight.	Cons. sand.	0.00	Very faint or none.	Very faintly mouldy.
3	8935	May 25	May 26	Very slight.	Slight, sandy.	0.00	Distinctly musty.	Very faint or none.
4	8936	May 25	May 26	Very slight.	Cons. sand.	0.00	Distinctly musty.	Very faint or none.
5	9039	June 28	June 29	Distinct, milky.	Slight.	0.02	Distinct.	Disagreeable and musty.
6	9040	June 28	June 29	None.	None.	0.00	None.	None.
7	9167	July 27	July 28	None.	Slight, fibrous.	0.04	Offensive.	Decidedly musty.
8	9168	July 27	July 28	None.	Very slight, fibrous.	0.02	Offensive.	V. dis'g'ble and musty.
9	9301	Aug. 23	Aug. 25	None.	Very slight.	0.00	Musty and disagreeable.	Musty and disagreeable.
10	9302	Aug. 23	Aug. 25	None.	Very slight.	0.00	Musty and disagreeable.	Musty and disagreeable.
11	9467	Sept. 28	Sept. 29	Distinct.	Slight, white.	0.05	Offensive.	Offensive.
12	9468	Sept. 28	Sept. 29	None.	Very slight.	0.00	Disagreeable and musty.	Decidedly disagreeable.
13	9566	Oct. 25	Oct. 26	Very slight.	None.	0.00	Decidedly musty.	Musty and mouldy.
14	9567	Oct. 25	Oct. 26	Distinct, milky.	Slight, white.	0.04	Decidedly musty.	Decidedly musty.
15	9736	Nov. 28	Nov. 29	Slight.	Slight.	0.00	Musty and offensive.	Musty and offensive.
16	9737	Nov. 28	Nov. 29	Slight.	Slight.	0.00	Musty and offensive.	Musty and offensive.
17	9818	Dec. 20	Dec. 21	None.	Slight, fibrous.	0.00	Distinctly disagreeable.	Unpleasant.
18	9819	Dec. 20	Dec. 21	Distinct, milky.	Slight.	0.05	Decidedly disagreeable.	Distinctly disagreeable.
		1893.						
19	9943	Jan. 26	Jan. 27	Distinct, milky.	Slight.	0.10	Offensive.	Offensive.
20	9945	Jan. 26	Jan. 27	None.	None.	0.02	Decidedly musty.	Decidedly musty.
21	10024	Feb. 15	Feb. 16	Distinct, milky.	Slight.	0.05	Offensive.	Offensive.
22	10025	Feb. 15	Feb. 16	Slight, milky.	Very slight.	0.03	Offensive.	Offensive.
23	10055	Feb. 27	Feb. 28	Milky.	Very slight.	0.10	Offensive.	Offensive.
24	10119	Mar. 14	Mar. 15	Slight.	Slight, fibrous.	0.05	Offensive.	Decidedly musty.
25	10120	Mar. 14	Mar. 15	Distinct.	Slight.	0.05	Offensive.	Offensive.
26	10184	Mar. 28	Mar. 29	Distinct.	Slight, white.	0.20	Decidedly offensive.	Decidedly offensive.
27	10183	Mar. 28	Mar. 29	Very slight.	Slight.	0.05	Distinct.	Decidedly musty.
28	10239	Apr. 11	Apr. 12	Distinct.	Slight.	0.02	Musty and offensive.	Musty and offensive.
29	10240	Apr. 11	Apr. 12	Slight.	Slight.	0.03	Musty and offensive.	Musty and disagreeable.
30	10328	Apr. 26	Apr. 28	Very slight.	None.	0.02	Offensive.	Decidedly musty.
31	10329	Apr. 26	Apr. 28	Very slight.	Slight, fibrous.	0.03	Offensive.	Offensive.
32	10382	May 10	May 11	Very slight.	Very slight.	0.02	Decidedly disagreeable	Decidedly musty.
33	10383	May 10	May 11	Very slight.	Very slight.	0.02	Decidedly disagreeable.	Decidedly musty.

Underdrains of the Marlborough Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	
	Free.	Albu-minoid.		Nitrates.	Nitrites.			
13.70	.0480	.0034	2.21	.5500	.0020	4.4	-	1
14.00	.0560	.0032	2.21	.5250	.0018	4.9	-	2
22.00	.0800	.0020	3.10	.5000	.0066	4.2	-	3
18.70	.1680	.0000	3.19	.4800	.0066	4.2	-	4
27.70	.0400	.0140	4.60	1.0000	.0160	6.5	-	5
20.30	.0144	.0038	3.42	.7500	.0020	4.9	-	6
29.30	.2800	.0160	6.53	1.1000	.0500	6.6	-	7
29.00	.4000	.0120	6.62	1.0500	.1000	6.4	-	8
39.10	.0046	.0070	6.53	.6000	.0200	7.1	-	9
26.40	.0560	.0042	5.80	.5000	.0120	6.6	-	10
27.60	.2000	.0370	5.37	.7000	.0200	8.0	.0040	11
27.40	.0800	.0040	5.56	.6000	.0100	7.7	.0000	12
33.00	.2400	.0120	6.27	1.0000	.2500	8.0	.0000	13
33.00	.3200	.0250	6.42	1.0000	.0300	8.4	.0040	14
31.40	.3200	.0170	5.53	1.2500	.0100	9.7	.0100	15
27.60	.2640	.0230	4.81	1.0000	.0200	8.8	.0020	16
27.80	.1240	.0120	5.60	1.2000	.0100	7.1	.0050	17
26.40	.8800	.0580	5.50	.6000	.0050	7.0	.0040	18
25.20	1.1200	.0620	5.83	.7000	.0040	6.1	.0000	19
27.40	.3440	.0110	6.10	.8000	.0100	7.4	.0000	20
24.10	.8000	.0480	5.38	.4000	.0120	8.4	.0160	21
22.30	.9800	.0320	5.24	.3000	.0050	7.1	.0060	22
24.00	1.0720	.0500	5.40	.3500	.0060	6.4	.0200	23
20.80	.6080	.0180	4.04	.2750	.0230	6.6	.0000	24
20.00	.8000	.0150	4.66	.2500	.0400	6.6	.0220	25
19.40	.5200	.0070	3.80	.3000	.0090	6.0	.0160	26
20.70	.5200	.0050	4.11	.4000	.0090	6.4	.0140	27
26.10	.3600	.0200	3.21	.0500	.0250	8.8	.0070	28
20.00	.8000	.0220	3.38	.4000	.0300	6.4	.0050	29
25.30	.1640	.0040	3.76	.9000	.0100	8.7	.0080	30
20.20	.4800	.0140	3.63	.4750	.0300	6.7	.0100	31
23.90	.1440	.0210	3.28	1.4000	.0140	7.7	.0070	32
24.20	.2000	.0130	3.37	1.4000	.0110	8.4	.0080	33

Chemical Examination of Effluent from the Under-

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.						
1	10448	May 24	May 26	Slight.	Cons., fibrous.	0.10	Decidedly musty.	Decidedly disagreeable.
2	10449	May 24	May 26	Slight.	Cons., fibrous.	0.15	Distinctly musty.	Distinctly musty.
3	10520	June 12	June 15	Slight.	Slight.	0.04	Offensive.	Offensive.
4	10521	June 12	June 15	Very slight.	Slight.	0.01	Offensive.	Decidedly musty.
5	10573	June 28	June 29	Distinct.	Cons., gray.	0.15	Offensive.	Offensive.
6	10574	June 28	June 29	Slight.	Slight.	0.05	Decidedly musty.	Offensive.
7	10638	July 10	July 11	Slight.	Slight, fibrous.	0.08	Offensive.	Offensive.
8	10639	July 10	July 11	Slight.	Slight, fibrous.	0.05	Decidedly musty.	Decidedly musty.
9	10711	July 26	July 28	Slight, milky.	Cons., fibrous.	0.02	Offensive.	Offensive.
10	10712	July 26	July 28	Decided, milky.	Heavy, fibrous.	0.15	Offensive.	Offensive.
11	Av.	....	....	....	....	0.04	....	....

The samples were collected from the underdrains beneath

Sewage Disposal at Gardner.

The Gardner sewerage system was put in operation about Aug. 1, 1891. At the close of the year there were ninety-seven connections with the sewers, and at the end of January, 1893, one hundred and thirty-nine connections, one hundred of which were from dwelling-houses and the remainder from factories, business blocks, hotels and public buildings. The population of the town in 1890 was 8,424. The principal industry is the manufacture of chairs. The town is made up of four villages so closely united as to form practically but one village. The total length of sewers constructed up to the end of January, 1893, was 5.87 miles.

The town is situated upon high land, and the greater portion of it naturally drains through Pond Brook into Otter River; this stream in turn empties into Miller's River, which flows into the Connecticut River from the east in the northerly portion of Massachusetts. The streams in the vicinity of the town (Pond Brook and Otter River) are so small that no considerable amount of crude sewage could be discharged into them without creating a nuisance; for this reason it became necessary to purify the sewage and it was decided to adopt intermittent filtration.

drains of the Marlborough Filter-beds — Concluded.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Hardness.	Iron.	
	Free.	Albuminoid.		Nitrates.	Nitrites.			
22.50	.3200	.0160	3.36	.7000	.0140	7.6	.0230	1
25.40	.1400	.0120	3.41	1.0000	.0080	8.1	.0200	2
20.60	.6000	.0340	4.36	.4000	.0200	5.7	.0050	3
27.30	.2600	.0090	4.20	1.2000	.0190	6.9	.0060	4
24.30	.6400	.0430	4.50	.4000	.0450	6.7	.0150	5
29.70	.4800	.0220	4.60	.8000	.0100	7.7	.0150	6
32.90	.6400	.0150	4.79	1.2000	.0500	7.8	.0750	7
36.70	.4800	.0270	4.77	2.0000	.1200	9.4	.0150	8
37.40	.6000	.0420	6.15	1.4000	.0350	8.1	.0120	9
31.40	.3400	.1050	6.20	1.0000	.0960	7.3	.0080	10
23.40	.3950	.0214	4.67	.7652	.0285	7.1	.0110	11

the beds to which sewage was being applied at the time.

Owing to the topography of the town, it was desirable to find a filtration area in the valley of Pond Brook, because the sewage from nearly the whole of the town could be brought to this place by gravity. The only porous ground to be found in this vicinity was a ridge of porous sand and gravel of limited extent located a short distance from the settled portion of the town. There is a large amount of porous land beyond the Otter River, and about a mile further from the town than this ridge, but it was thought better to adopt the nearer location in the beginning.

In constructing the sewers provision was made for taking roof water for flushing purposes from a limited number of buildings at the upper ends of the sewers, but with this exception all surface water is excluded. Special care was taken to prevent the entrance of ground water, by making tight joints between the sewer pipes. The main sewer leading from the town is twelve inches in diameter; and the last 1,050 feet, where it crosses the valley of Pond Brook, is of iron pipe laid as an inverted siphon. The quantity of sewage is not definitely known, but it is probably in the neighborhood of 125,000 gallons per day.

The tract purchased by the town for the disposal of the sewage contains 16.9 acres, which includes the ridge of sand and gravel before mentioned. Much of the material upon this tract was found to be too fine for the filtration of sewage, and as a result the filter-beds are almost wholly artificial, being formed of the porous sand and gravel from the ridge. There are twelve thoroughly underdrained filter beds for the disposal of sewage, having a total area of 1.39 acres, two supplementary beds which are less porous and not underdrained, having a total area of 0.37 acres, and two other small, underdrained beds, containing together 0.14 acres. One of these small beds is used to receive the sludge from the sludge tank, and the other to receive the discharge from a blow-off at the lowest point in the inverted siphon. The effective size of the sand of the artificial beds is somewhat greater than at Marlborough, but much finer than at Framingham.

The sewage when it reaches the disposal area first passes through duplicate separating tanks, each twenty feet long, seven feet wide and five feet deep, and the overflow from these tanks passes through pipes into wooden troughs, from which the sewage is discharged upon the filter-beds. The underdrains are generally twenty feet apart, and at a depth of from four to five feet below the surface of the beds. It will be noticed from the figures already given that the filtration area has been divided into much smaller beds than are in use at Marlborough and Framingham. This feature was adopted with a view to the more even distribution of the sewage over the

Chemical Examination of

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1891.										
1	8005	Oct. 3	Oct. 6	Decided, milky.	Much, white.	0.50	16.10	13.80	2.30	5.90	3.80	2.10
		1892.										
2	8826	Apr. 29	Apr. 30	Decided.	Heavy, gray.	0.70	27.50	17.70	9.80	16.00	8.70	7.30
3	8950	May 31	June 1	Decided.	Heavy.	0.20	17.60	13.40	4.20	6.00	3.00	3.00
4	9011	June 15	June 16	Decided.	Heavy.	0.55	34.85	18.75	16.10	18.75	6.65	12.10

surface of the beds. It was the custom at one time to use one-half of the beds in rotation one day and the other half the next; whether this custom is followed at the present time is not known. Every bed is provided with an overflow, to prevent the sewage from washing away the banks if it should at any time rise too high in the beds.

The results obtained at Gardner in the disposal of sewage have been satisfactory in summer, as it has been found feasible to dispose of all of the sewage by filtration, and a fair degree of purification has been attained. In order to obtain these results, it has been necessary to attend carefully to the distribution of the sewage upon the different beds, and to prevent a scum from forming upon them. During the cold weather of winter, when the removal of this scum is prevented by snow and ice upon the beds, it has not been found practicable to filter the sewage upon the small area which is provided, and a portion of it has overflowed into the brook. The analyses show that eighty-nine per cent. of the organic matter, as represented by the albuminoid ammonia, is removed from the sewage by filtration.

The winter temperature of the sewage is somewhat lower than at Marlborough and much lower than at Framingham; and, as Gardner is located further north than either of these places, and at a greater distance from the sea, the mean temperature of the air in winter is also lower. It is probable, however, that even under these conditions the sewage could all be filtered in winter if the area of filter-beds was sufficiently large.

Sewage from Gardner.

[Parts per 100,000.]

Ammonia.					Nitrogen as			Iron.		
	Albuminoid.									
Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.	Unfiltered.	Filtered.	
1.6000	.1800	.0800	.1000	1.77	.1100	.0140	4.3	-	-	1
1.8400	.3360	.2000	.1360	2.22	.0050	.0150	3.8	-	-	2
.8320	.2330	.1270	.1060	2.40	.0020	.0150	3.4	-	-	3
2.2000	.2820	.1540	.1280	2.80	.0050	.0000	-	-	-	4

Chemical Examination of

[Parts per 100,000.]

		Date of		Appearance.			Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
	Number.	Collection.	Examination.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1892.										
1	9055	June 30	July 1	Decided.	Heavy.	0.70	22.10	14.10	8.00	-	4.20*	-
2	9097	July 12	July 13	Decided.	Heavy, brown.	0.70	32.40	21.00	11.40	18.00	12.20	5.80
3	9186	Aug. 1	Aug. 2	Decided.	Heavy, gray.	0.80	27.20	19.60	7.60	14.20	6.70	7.50
4	9221	Aug. 9	Aug. 10	Thick.	Heavy, gray.	0.50	25.90	17.80	8.10	14.70	8.30	6.40
5	9306	Aug. 25	Aug. 25	Decided.	Heavy, gray.	0.50	25.60	16.00	9.60	13.10	6.20	6.90
6	9362	Sept. 13	Sept. 14	Decided.	Heavy, gray.	0.50	26.70	18.30	8.40	14.30	7.80	6.50
7	9474	Sept. 29	Sept. 29	Thick, milky.	Heavy.	0.70	27.30	19.70	7.60	15.90	9.20	6.70
8	9517	Oct. 11	Oct. 12	Decided.	Heavy.	0.70	27.80	17.80	10.00	16.20	7.90	8.30
9	9578	Oct. 26	Oct. 27	Decided.	Heavy, gray.	0.70	30.20	20.60	9.60	17.60	9.10	8.50
10	9671	Nov. 14	Nov. 15	Thick.	Heavy, gray.	0.80	43.90	26.90	17.00	26.50	12.30	14.20
11	9733	Nov. 28	Nov. 29	Thick.	Heavy, dirty.	0.55	41.60	22.60	19.00	27.70	11.30	16.40
12	9783	Dec. 12	Dec. 13	Thick.	Heavy.	0.70	36.10	24.10	12.00	22.10	11.90	10.20
13	9825	Dec. 21	Dec. 22	Thick.	Heavy.	0.70	30.00	22.10	7.90	18.40	10.70	7.70
		1893.										
14	9886	Jan. 16	Jan. 17	Thick.	Heavy, gray.	0.90	44.40	31.90	12.50	26.30	15.60	10.70
15	9937	Jan. 25	Jan. 26	Decided, thick.	Heavy.	0.80	30.20	20.30	9.90	20.20	10.90	9.30
16	9973	Feb. 6	Feb. 7	Decided, thick.	Heavy.	0.50	42.90	23.90	19.00	27.90	11.80	16.10
17	10044	Feb. 27	Feb. 28	Decided.	Cons., gray.	0.40	30.00	23.00	7.00	17.40	11.50	5.90
18	10116	Mar. 14	Mar. 15	Decided.	Cons., gray.	0.40	14.60	9.20	5.40	6.00	4.10	1.90
19	10180	Mar. 28	Mar. 29	Thick, milky.	Heavy.	0.30	19.00	13.60	5.40	10.60	6.50	4.10
20	10234	Apr. 11	Apr. 12	Decided, milky.	Heavy, gray.	0.50	23.30	15.60	7.70	12.40	6.00	6.40
21	10320	Apr. 26	Apr. 27	Decided	Heavy, gray.	0.40	21.90	14.80	7.10	10.50	5.30	5.20
22	10379	May 10	May 11	Decided, milky.	Heavy, white.	0.40	20.00	14.90	5.10	9.10	4.70	4.40
23	10445	May 24	May 25	Distinct, milky.	Cons., gray,	0.40	22.40	15.70	6.70	11.20	5.10	6.10
24	10505	June 12	June 13	Decided.	Heavy, gray.	0.50	33.90	20.00	13.90	19.10	9.30	9.80
25	10570	June 28	June 29	Decided, greasy.	Heavy, gray.	0.50	40.10	22.00	18.10	23.30	9.80	13.50
26	10654	July 12	July 13	Decided, opaque.	Heavy.	0.60	25.90	16.00	9.90	15.40	7.50	7.90
27	10700	July 26	July 27	Decided.	Heavy, gray.	0.50	26.00	16.60	9.40	14.20	7.00	7.20
28	Av.	....	....	....	....	0.57	28.63	18.77	9.86	16.30	8.36	7.94

Odor, offensive.—— The sewage was

* This determination is not included in the average.

Sewage from Gardner — Concluded.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.		
	Albuminoid.									
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		Unfiltered.	Filtered.	
2.5600	.3730	.2180	.1550	2.78	.0050	.0001	3.6	–	–	1
1.9840	.4840	.2140	.2700	2.78	.0050	.0001	3.9	–	–	2
.8000	.1650	.0800	.0850	2.78	.0020	.0001	–	–	–	3
2.0960	.3680	.1980	.1700	2.76	.0050	.0001	5.3	–	–	4
2.0000	.2850	.1880	.0970	2.44	.0030	.0000	4.6	–	–	5
1.2800	.4360	.1820	.2540	2.25	.0030	.0005	2.7	.0210	–	6
1.9200	.4800	.2740	.2060	2.26	.0050	.0001	3.1	.0850	.0750	7
.9600	.3640	.2190	.1450	2.22	.0050	.0000	3.7	.1100	.0430	8
1.9840	.5960	.3100	.2860	3.38	.0050	.0000	3.5	.0800	.0600	9
1.6000	.6160	.3480	.2680	2.80	.0000	.0000	5.4	.1850	.0540	10
1.3760	.5700	.2880	.2820	2.59	.0500	.0020	4.3	.1650	.0700	11
1.3440	.5320	.3400	.1920	2.78	.0050	.0000	3.8	.1100	.0620	12
2.2720	.5700	.3540	.2160	2.76	.0200	.0060	3.2	.0760	.0460	13
2.4000	.6640	.4000	.2640	5.62	.0050	.0012	3.1	.0850	.0350	14
1.9200	.5340	.3240	.2100	2.58	.0100	.0025	2.6	.0840	.0300	15
1.7920	.5340	.3160	.2180	3.40	.0100	.0050	3.0	.0800	.0250	16
2.0800	.6260	.3860	.2400	3.44	.0200	.0040	3.4	.0500	.0350	17
.4880	.1460	.0920	.0540	1.40	.0600	.0009	2.2	.1400	.0360	18
.8000	.2400	.1680	.0720	2.30	.0180	.0060	2.9	.0700	.0300	19
1.3600	.2720	.1760	.0960	2.10	.0750	.0250	3.0	.0250	.0150	20
.9600	.2920	.1500	.1420	2.22	.0500	.0170	3.0	.0550	.0450	21
1.1200	.2960	.1320	.1640	2.37	.0090	.0020	3.6	.0200	.0100	22
1.2800	.2280	.1260	.1020	2.18	.0000	.0020	3.5	.0500	.0120	23
2.0000	.5820	.2000	.3820	2.67	.0000	.0010	3.9	.0800	.0200	24
1.7600	.5000	.1900	.3100	3.47	.0000	.0000	3.8	.0750	.0150	25
2.2400	.3240	.1980	.1260	2.72	.0070	.0010	4.3	.0500	.0220	26
2.4000	.4320	.2780	.1540	3.20	.0050	.0010	4.6	.0550	.0180	27
1.6531	.4045	.2229	.1816	2.69	.0163	.0039	3.6	.0796	.0361	28

collected as it flowed upon the beds.

Chemical Examination of Effluent from the

[Parts per 100,000.]

	Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1891.						
1	8007	Oct. 3	Oct. 6	Distinct.	Cons., white.	0.80	Offensive.	Offensive.
		1892.						
2	8827	Apr. 29	Apr. 30	Slight, milky.	Considerable.	0.15	Offensive.	Offensive.
3	8900	May 16	May 17	Distinct.	Considerable.	0.02	Offensive.	Offensive.
4	8901	May 16	May 17	Distinct.	Considerable.	0.02	Offensive.	Offensive.
5	8949	May 31	June 1	Distinct.	Slight.	0.02	Offensive.	Musty.
6	9012	June 15	June 16	Distinct.	Cons., fibrous.	0.20	Offensive.	Offensive.
7	9056	June 30	July 1	Decided, milky.	Cons., mouldy.	0.40	Distinctly musty.	Musty and disagreeable.
8	9098	July 12	July 13	Distinct, milky.	Slight, gray.	0.10	Offensive.	Offensive.
9	9187	Aug. 1	Aug. 2	Distinct.	Considerable.	0.15	Musty and disagreeable.	Musty and disagreeable.
10	9222	Aug. 9	Aug. 10	Decided.	Heavy, red.	1.00	Vegetable and musty.	Offensive and musty.
11	9307	Aug. 25	Aug. 25	Slight.	Cons., rusty.	0.50	Offensive.	Offensive.
12	9363	Sept. 13	Sept. 14	Distinct.	Cons., white.	0.10	Musty and disagreeable.	Musty and disagreeable.
13	9475	Sept. 29	Sept. 30	Slight, milky.	Very slight.	0.02	Distinctly musty.	Musty and disagreeable.
14	9518	Oct. 11	Oct. 12	Slight.	Slight, rusty.	0.00	Distinctly musty.	Decidedly musty.
15	9579	Oct. 26	Oct. 27	Slight, milky.	Very slight.	0.05	Musty and disagreeable.	Musty and disagreeable.
16	9672	Nov. 14	Nov. 15	Slight.	Slight, sandy.	0.02	Musty and disagreeable.	Musty and disagreeable.
17	9734	Nov. 28	Nov. 29	Distinct, milky.	Slight.	0.05	Musty and offensive.	Musty and offensive.
18	9784	Dec. 12	Dec. 13	Very slight, milky.	None.	0.04	Very faint or none.	Very faintly musty.
19	9826	Dec. 21	Dec. 22	Slight, milky.	Slight.	0.05	Offensive.	Very disagreeable.
		1893.						
20	9887	Jan. 16	Jan. 17	Decided, milky.	Slight.	0.20	Offensive.	Offensive.
21	9938	Jan. 25	Jan. 26	Decided.	Cons., white.	0.60	Offensive.	Offensive.
22	9974	Feb. 6	Feb. 7	Distinct.	Cons., light.	0.50	Offensive.	Offensive.
23	10045	Feb. 27	Feb. 28	Decided.	Considerable.	0.30	Musty and disagreeable.	Offensive.
24	10117	Mar. 14	Mar. 15	Decided.	Considerable.	0.40	Offensive.	Offensive.
25	10181	Mar. 28	Mar. 29	Decided.	Slight.	0.20	Musty and unpleasant.	Musty and offensive.
26	10235	Apr. 11	Apr. 12	Distinct.	Cons., yellow.	0.30	Offensive.	Offensive.
27	10321	Apr. 26	Apr. 27	Very slight.	None.	0.02	Offensive.	Decidedly musty.
28	10380	May 10	May 11	Very slight, milky.	Slight.	0.08	Decidedly disagreeable.	Decidedly musty.
29	10446	May 24	May 25	Very slight.	Very slight.	0.08	Offensive.	Offensive.
30	10506	June 12	June 13	Slight, milky.	None.	0.05	Offensive.	Offensive.
31	10571	June 28	June 29	Distinct, milky.	Slight.	0.03	Offensive.	Offensive.
32	10655	July 12	July 13	Slight, milky.	Slight.	0.02	Distinctly musty.	Musty and disagreeable.
33	10701	July 26	July 27	Dis't, milky.	Slight, white.	0.02	Musty & of've.	Offensive.
34	Av.	....	....	....	....	0.20	....	....

The samples were collected from the main underdrain

Main Underdrain of the Gardner Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Hardness.	Iron.	
Total Residue.			Loss on Ignition.			Free.	Albuminoid.								
Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.		Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.			
14.60	-	-	3.75	-	-	2.0800	.0600	.0400	.0200	2.80	.2500	.0250	3.5	-	1
15.00	14.70	0.30	4.40	4.20	0.20	.9600	.0100	.0060	.0040	2.96	.3500	.0420	4.2	-	2
14.05	-	-	4.65	-	-	.6520	.0330	.0240	.0090	2.19	.4500	.0270	4.2	-	3
13.35	-	-	3.70	-	-	.6400	.0380	.0330	.0050	2.21	.4500	.0350	4.0	-	4
6.00	-	-	1.75	-	-	.4400	.0560	.0270	.0290	2.04	.2500	.0600	3.7	-	5
27.55	22.55	5.00	15.35	10.85	4.50	.5600	.0870	.0560	.0310	2.40	.7000	.1200	-	-	6
20.40	19.50	0.90	7.80	7.30	0.50	.7200	.0560	.0360	.0200	2.60	.8000	.5000	5.3	-	7
15.80	-	-	5.60	-	-	.3200	.0200	-	-	2.30	.8000	.0010	4.0	-	8
27.40	17.40	10.00	13.50	6.20	7.30	.2480	.0250	.0160	.0090	2.20	.7000	.4000	-	-	9
16.60	14.80	1.80	5.10	4.50	0.60	.7200	.0820	.0480	.0340	2.68	.1000	.0100	4.0	-	10
18.40	-	-	-	-	-	.3200	.0310	-	-	2.58	.8000	.0800	5.3	-	11
24.60	-	-	11.10	-	-	.2480	.0760	.0580	.0180	2.29	1.1000	.0500	6.1	.0075	12
24.20	-	-	-	-	-	.1560	.0120	-	-	2.37	1.2000	.0100	6.6	.0050	13
21.20	-	-	-	-	-	.1920	.0120	-	-	2.55	1.2000	.1000	4.8	.0050	14
16.40	-	-	-	-	-	.2520	.0210	-	-	2.77	.8000	.0300	3.8	.0080	15
14.20	-	-	-	-	-	.6600	.0310	-	-	2.40	.5000	.0400	3.6	.0040	16
13.80	-	-	-	-	-	.3800	.0300	-	-	1.76	.7500	.0200	3.2	.0140	17
14.10	-	-	-	-	-	.4800	.0280	-	-	2.03	.5500	.0500	3.5	.0010	18
13.80	-	-	-	-	-	.9800	.0430	-	-	2.29	.4500	.0020	2.7	.0050	19
12.20	-	-	-	-	-	1.2000	.0940	-	-	2.64	.0300	.0100	3.4	.0140	20
13.30	-	-	-	-	-	.6000	.1290	-	-	2.43	.0300	.0020	2.8	.0520	21
12.20	-	-	-	-	-	1.5200	.1430	-	-	2.36	.0250	.0040	2.8	.0820	22
10.40	-	-	-	-	-	.9600	.1020	-	-	2.20	.0900	.0030	2.7	.1280	23
6.40	-	-	-	-	-	.4800	.0390	-	-	1.34	.0750	.0080	2.6	.0820	24
7.60	-	-	-	-	-	.4160	.0120	-	-	1.68	.1500	.0080	2.6	.0400	25
10.50	-	-	-	-	-	.6400	.0670	-	-	1.83	.1500	.0160	2.7	.0380	26
10.70	-	-	-	-	-	.4800	.0210	-	-	2.02	.3250	.0020	3.0	.0000	27
14.20	-	-	-	-	-	.4000	.0180	-	-	2.31	.5000	.0040	4.6	.0100	28
14.10	-	-	-	-	-	.5200	.0190	-	-	1.63	.0950	.0150	4.1	.0120	29
22.20	-	-	-	-	-	.0880	.0280	-	-	1.82	1.8000	.0120	5.3	.0220	30
14.70	-	-	-	-	-	.1600	.0240	-	-	2.56	.4500	.0400	4.2	.0050	31
17.50	-	-	-	-	-	.1200	.0200	-	-	1.74	1.0000	.0900	4.3	.0150	32
15.00	-	-	-	-	-	.1080	.0360	-	-	1.55	1.0000	.0020	4.4	.0100	33
15.53	-	-	6.97	-	-	.5667	.0455	-	-	2.23	.5430	.0551	3.9	.0254	34

at the point where it discharges into the brook.

REPORT UPON ARTIFICIAL ICE.

Report on Artificial Ice Made in Massachusetts.

The following report was transmitted to the Legislature May 16, 1893, in compliance with an order directing the Board to "extend its investigation upon the impurities of ice, to manufactured ice, and report thereon."

In accordance with the order of the General court, the State Board of Health has had its chemist, Prof. T. M. Drown, examine the artificial ice made in Massachusetts, and submits the following report.

There are three firms which make ice for sale in Massachusetts, namely, the Brookline Artificial Ice Company in Brighton, the Oak Grove Farm Company in Boston, and the Boston Hygeia Ice Company in Brockton. The Brockton Crystal Ice Company uses the same plant as the Boston Hygeia Ice Company.

All these corporations use the ammonia system of freezing. Galvanized-iron tanks, holding from two hundred to two hundred and fifty pounds of water, are immersed in brine, which is cooled below the freezing point of water by pipes which convey the gaseous ammonia. The freezing goes on slowly from the sides of the tanks, and it generally requires about two days to form a solid cake of ice.

At the plants of the Boston Hygeia Ice Company and the Oak Grove Farm Company distilled water is used to make the ice; but at the plant of the Brookline Artificial Ice Company in Brighton the water of the Undine Spring is simply boiled before freezing. The distilled water is generally condensed steam from the engine, which is filtered through various media, such as sand, coke and charcoal, to free it from oil, grease and other suspended matters, and it is subsequently boiled, to expel the air. Water containing air will give bubbly ice; the more completely the water is freed from air, the clearer and more compact the ice will be.

The water in all three of the plants is obtained from wells sunk on the premises. Analyses of these waters are given below, in connection with the analyses of the ice. It will be noted that they all contain considerable mineral matter in solution; but in those cases where the water is converted into steam, and only the condensed water used for ice making, the original composition of the water is of comparatively little consequence. Well water is preferred to surface water, for the reason that the latter, on account of the vegetable matter it generally contains, would be likely to communicate an odor to the distilled water made from it, and this odor would be noticeable in the ice.

The twenty-first annual report of the Board, for the year ending Sept. 30, 1889, contained a report of investigations upon the pollution of natural ice supplies. As the result of these investigations, it was shown that, in the process of slow freezing in lakes and ponds, the elimination of dissolved mineral substances was nearly complete, and that of the dissolved organic matter in the water (as indicated by the ammonias), only six per cent. remained in the clear ice formed below the surface.

In the process of making artificial ice, it is obvious that the ice block, *as a whole*, must have identically the same composition as the water from which it was made; but we should expect that, in the slow process of freezing, the ice layers first formed would (if the water contained any dissolved impurities) be purer than the original water, and that the impurities would be gradually concentrated in the remaining water. This we find to be the case, and the inevitable result is, that the portion of ice last formed contains the impurities of the water in a highly concentrated condition.

In order to show this, all of the blocks of ice examined were divided into six portions, and each portion, after melting, was analyzed separately. These portions represented the upper, middle and lower thirds of the outside, and the upper, middle and lower thirds of the inner core. In nearly all cases it was found that the lower third of the core contained the greater part of the impurities originally present in the water.

This is most strongly marked in the case of the block of ice from the Brookline Artificial Ice Company, which is made from boiled spring water containing a good deal of dissolved mineral matter. In the other two cases, the amount of dissolved matter

in the distilled water being very small, the concentration is less noticeable.

It is interesting in this connection to note that the sample of distilled water taken at the Oak Grove Farm Company's plant from the rubber hose used to fill the tanks had a faint odor of rubber. This odor was quite marked in ice taken from the lower portion of the core, while in the upper portions of the ice no odor was perceived.

In the following tables are given the results of the analyses of the well waters and of the waters used for freezing, in connection with the analyses of the blocks of ice, divided into six portions, as described above: —

OAK GROVE FARM COMPANY, BOSTON — *Water from Wells on the Premises.*

[Parts per 100,000.]

		Number.	Date of Collection.	Date of Examination.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
			1893.						
1	- -	10290	Apr. 24	Apr. 25	None.	V. slight.	0.00	None.	None.

Distilled Water used for Freezing.

2	- -	10291	Apr. 24	Apr. 25	None.	V. slight.	0.00	Distinct, of rubber hose.	Very faint, of rubber hose.

Block of Ice.

3	Outer layer, upper third.	10292	Apr. 24	Apr. 25	None.	None.	0.02	None.	None.
4	Outer layer, middle third.	10293	Apr. 24	Apr. 25	None.	None.	0.00	None.	None.
5	Outer layer, lower third.	10294	Apr. 24	Apr. 25	None.	V. slight.	0.00	Faint, of rubber hose.	Faint, of rubber hose.
6	Inner core, upper third.	10295	Apr. 24	Apr. 25	None.	V. slight.	0.00	None.	None.
7	Inner core, middle third.	10296	Apr. 24	Apr. 25	None.	V. slight.	0.00	None.	None.
8	Inner core, lower third.	10297	Apr. 24	Apr. 25	None.	V. slight.	0.00	Decided, of rubber hose.	Distinct, of rubber hose.

BOSTON HYGEIA ICE COMPANY, BROCKTON — *Water from Artesian Well.*

			1893.						
1	- -	10325	Apr. 28	Apr. 28	None.	None.	0.00	None.	None.

Distilled Water used for Freezing.

2	- -	10326	Apr. 28	Apr. 28	None.	None.	0.00	None.	None.

Block of Ice.

3	Outer layer, upper third.	10286	Apr. 21	Apr. 22	None.	V. slight, white.	0.00	None.	None.
4	Outer layer, middle third.	10285	Apr. 21	Apr. 22	None.	None.	0.00	None.	None.
5	Outer layer, lower third.	10284	Apr. 21	Apr. 22	None.	Slight, white.	0.00	None.	None.
6	Inner core, upper third.	10289	Apr. 21	Apr. 22	None.	V. slight, brown.	0.00	None.	None.
7	Inner core, middle third.	10288	Apr. 21	Apr. 22	None.	Slight, brown.	0.00	None.	None.
8	Inner core, lower third.	10287	Apr. 21	Apr. 22	None.	Cons., gray.	0.00	None.	None.

OAK GROVE FARM COMPANY, BOSTON — *Water from Wells on the Premises* — Concluded.

[Parts per 100,000.]

Residue on Evaporation.		Ammonia.			Nitrogen as						
Total.	Loss on Ignition.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Hardness.	Oxygen Consumed.	Iron.	Zinc.	
68.00	-	.0414	.0028	14.96	2.2000	.0006	14.1	.0438	.0120	-	1
Distilled Water used for Freezing — Concluded.											
0.70	-	.0174	.0000	.02	.0000	.0000	0.0	.0328	.0000	-	2
Block of Ice — Concluded.											
0.35	-	.0016	.0000	.02	.0000	.0000	0.0	.0036	.0000	None.	3
0.52	-	.0010	.0000	.02	.0000	.0000	0.3	.0000	.0000	None.	4
0.80	-	.0108	.0006	.33	.0000	.0000	0.2	.0292	.0000	Traces.	5
0.36	-	.0094	.0006	.06	.0000	.0900	0.0	.0073	.0000	None.	6
0.16	-	.0114	.0000	.05	.0000	.0000	0.0	.0182	.0000	None.	7
0.72	-	.0250	.0016	.15	.0050	.0001	0.0	.0255	.0000	Traces.	8

BOSTON HYGEIA ICE COMPANY, BROCKTON — *Water from Artesian Well* — Concluded.

26.40	-	.0926	.0028	4.51	.5000	.0028	7.9	.0584	.0050	-	1
Distilled Water used for Freezing — Concluded.											
0.48	-	.0450	.0030	0.03	.0200	.0013	0.0	.0584	.0000	-	2
Block of Ice — Concluded.											
0.60	-	.0122	.0006	0.00	.0000	.0004	0.0	.0109	.0020	Traces.	3
0.00	-	.0058	.0000	0.00	.0030	.0002	0.0	.0073	.0000	None.	4
0.60	-	.0060	.0000	0.00	.0000	.0002	0.0	.0000	.0016	Traces.	5
0.00	-	.0146	.0004	0.00	.0000	.0015	0.0	.0000	.0000	None.	6
0.32	-	.0078	.0004	0.00	.0000	.0003	0.0	.0000	.0040	None.	7
1.16	-	.0366	.0014	0.01	.0070	.0027	0.0	.0073	.0084	.1600	8

BROOKLINE ARTIFICIAL ICE COMPANY, BRIGHTON — *Water from Undine Spring.*

[Parts per 100,000.]

			Date of		Appearance.			Odor.	
		Number.	Collection.	Exam-ination.	Turbidity.	Sediment.	Color.	Cold.	Hot.
			1893.						
1	- -	10303	Apr. 25	Apr. 26	None.	None.	0.00	None.	None.

Undine Spring Water, boiled and filtered, used for Freezing.

2	- -	10304	Apr. 25	Apr. 26	None.	None.	0.0	None.	None.

Block of Ice.

3	Outer layer, upper third.	10305	Apr. 25	Apr. 26	None.	Sl't, dark-colored particles.	0.00	None.	None.
4	Outer layer, middle third.	10306	Apr. 25	Apr. 26	None.	None.	0.00	None.	None.
5	Outer layer, lower third.	10307	Apr. 25	Apr. 26	V. slight.	Cons., white.	0.00	None.	None.
6	Inner core, upper third.	10308	Apr. 25	Apr. 26	None.	Slight, white.	0.00	None.	None.
7	Inner core, middle third.	10309	Apr. 25	Apr. 26	V. slight, white.	Cons., white.	0.00	None.	None.
8	Inner core, lower third.	10310	Apr. 25	Apr. 26	Distinct, white.	Heavy, white.	0.03*	None.	Faintly earthy.

* Filtered.

The number of bacteria in all the samples of ice was very low, and in many there were none present.

In the case of the ice from the Brookline Artificial Ice Company, in which, by reason of the large amount of dissolved matter in the water, the segregation of the impurities can be best studied, it will be noticed that the lower third of the interior of the block of ice contained a very large amount of mineral matter. This portion when melted was quite turbid, and deposited a heavy white sediment on standing, consisting mainly of silica. The small amount of organic matter present originally in the water is also found here in a more concentrated form, as shown by the albuminoid ammonia and by the oxygen consumed.

This concentration of the impurities of a water in the process of artificial freezing is a matter of great importance, and it is obvious that only pure waters are adapted for the process. Distilled water leaves nothing to be desired in this respect.

BROOKLINE ARTIFICIAL ICE COMPANY, BRIGHTON — *Water from Undine Spring* — Concluded.

[Parts per 100,000.]

Residue on Evaporation.		Ammonia.			Nitrogen as						
Total.	Loss on Ignition.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Hardness.	Oxygen Consumed.	Iron.	Zinc.	
15.30	-	.0000	.0030	2.18	.6000	.0000	3.8	.0620	.0000	-	1
Undine Spring Water, boiled and filtered, used for Freezing — Concluded.											
18.04	-	.0110	.0010	3.45	.7500	.0200	4.4	.0547	.0008	-	2
Block of Ice — Concluded.											
0.44	-	.0044	.0008	0.04	.0000	.0002	0.0	.0073	.0000	None.	3
0.24	-	.0032	.0002	0.05	.0000	.0000	0.0	.0109	.0000	None.	4
4.00	-	.0052	.0000	0.44	.1100	.0030	1.6	.0036	.0012	.2000	5
4.48	-	.0102	.0000	0.72	.1800	.0130	1.4	.0255	.0000	None.	6
14.76	-	.0262	.0016	3.27	1.0000	.0700	4.9	.0730	.0008	None.	7
70.60 61.10*	-	.0602	.0082	11.59	1.6000	.2800	21.0	.2993	.0045	.2400	8

* The second determination of the total residue on evaporation was made of the water filtered through paper in the laboratory.

The fitness of a natural water for freezing must depend on its purity. It would be seldom that even a well water could be found which would not give an objectionable degree of concentration of mineral matter in the portion last frozen.

Although it cannot be said that the ice from the Brookline Artificial Ice Company would prove injurious, yet water with 70 parts of solids and a hardness equivalent to 21 parts per 100,000 of carbonate of lime is certainly not a desirable drinking water for those who are accustomed to a soft water. It was said by this company that they were preparing to use distilled water only.

The free ammonia present in all the samples of ice may fairly be supposed to come from slight leakage of the machine. It is safe to say that, in the absence of other evidence of organic contamination, it has no significance.

In many of the samples an appreciable amount of zinc was found. This can only have its origin in the zinc coating of the galvanized

pipes used to conduct the water, or in the coating of the tanks in which the water is frozen. The largest amount found was .2400 parts of metallic zinc per 100,000, which is equal to 0.14 grain per gallon.

The Board therefore concludes that: —

1. Artificial processes of freezing concentrate the impurities of the water in the inner core or the portion last frozen.

2. The impurities are reduced to their lowest terms by the use of distilled water (condensed steam) for the manufacture of ice.

3. The number of bacteria in artificial ice is insignificant, under the prevailing methods of manufacture.

4. The amount of zinc found in the samples of melted artificial ice under observation is insufficient to injure the health of persons using such ice.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The work of the year ending Sept. 30, 1892, completes a period of ten years since the food and drug statute of 1882 was enacted. In the following report a brief *résumé* of some of the important points relating to the operation of this law during the past decade will be presented.

Before the close of the financial year ending Sept. 30, 1891, it was deemed advisable to place all the analytical work in this department under one head, as far as was possible, and for this purpose Dr. Charles P. Worcester was appointed to take charge of all the analytical work, except the examination of milk collected in the four western counties of the State, which is conducted by Prof. C. A. Goessmann at Amherst, Mass.

The following constituted the working force of analysts and inspectors during the year: —

Dr. Charles P. Worcester,	*Analyst.*
Prof. Charles A. Goessmann,	*Analyst.*
Mr. Albert E Leach,	*Assistant Analyst.*
John H. Terry,	*Inspector.*
John F. McCaffrey,	*Inspector.*
Horace F. Davis,	*Inspector.*

The whole number of samples of food and drugs examined during the year was 6,199, making the whole number examined under the provisions of the food and drug acts 47,164 for the ten years ending Sept. 30, 1892.

The following summary embraces the work done during the year, classified: —

Number of samples of food examined,	5,712
Number of samples of food found to be pure,	3,799
Number of samples of food found to be adulterated, or not conforming to the standard,	1,913
Percentage of adulteration,	33.5

Number of samples of milk examined (included above),	3,271
Number of samples of milk examined above standard,	1,757
Number of samples of milk examined below standard,	1,514
Percentage below standard, or otherwise adulterated,	46.3
Number of samples of drugs examined,	487
Number of samples of drugs of good quality,	312
Number of samples of drugs adulterated,	175
Percentage of adulteration,	35.9
Total examinations of food and drugs,	6,199
Total examinations of good quality,	4,111
Total examinations not conforming to the statutes,	2,088
Percentage of adulteration,	33.7

The following table presents the general statistics of the work of the Board in this direction for the entire period of ten years, during which the work of food and drug inspection has been conducted: —

STATISTICAL SUMMARY.

Food and Drug Inspection, Ten Years (1883–92).

Summary.	Years.										Total.
	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	
Number of samples of food examined,	695	1,962	3,771	3,438	4,870	4,904	4,854	5,585	4,870	5,712	40,661
Number of samples found to be pure,	363	779	2,180	2,186	3,163	3,385	3,213	3,771	3,206	3,799	26,045
Number of samples found to be adulterated, or not conforming to the statutes,	332	1,183	1,591	1,252	1,707	1,519	1,641	1,814	1,664	1,913	14,616
Percentage of adulteration,	47.8	60.3	40.3	36.4	35.1	30.9	33.8	32.5	34.2	33.5	35.9
Number of samples of milk examined (included above),	218	1,123	2,219	2,085	3,081	2,825	3,219	3,236	2,726	3,271	24,003
Number of samples above standard,	35	347	1,297	1,323	1,900	1,705	1,971	1,858	1,629	1,757	13,822
Number of samples below standard,	183	776	922	762	1,181	1,120	1,248	1,378	1,097	1,514	10,181
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	39.6	38.7	42.6	40.2	46.3	42.4
Number of samples of drugs examined,	603	682	1,007	888	550	862	600	400	424	487	6,503
Number of samples of good quality,	357	431	571	463	400	634	503	325	352	312	4,348
Number of samples adulterated, as defined by the statutes,	246	251	436	425	150	228	97	75	72	175	2,155
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	26.4	16.2	18.7	17.0	35.9	33.1
Total examinations of food and drugs,	1,298	2,644	4,778	4,326	5,420	5,766	5,454	5,985	5,294	6,199	47,164
Total examinations of good quality,	720	1,210	2,751	2,649	3,563	4,019	3,716	4,096	3,558	4,111	30,393
Total examinations not conforming to the statutes,	578	1,434	2,027	1,677	1,857	1,747	1,738	1,889	1,736	2,088	16,771
Percentage of adulteration,	44.5	54.2	42.7	38.7	34.3	30.3	31.9	31.5	32.8	33.7	35.5
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41	$10,356 28	$10,013 04	$10,019 41	$11,180 30	$84,331 99
Expense of collection, examination and prosecution, per sample,	2 26	2 09	1 79	1 85	1 62	1 54	1 89	1 67	1 89	1 80	1 79

The whole number of samples collected for examination during the year was greater than that of any previous year since the beginning of this work by the Board.

It has been repeatedly stated in former reports of the Board that but little can be learned as to the actual ratio of adulteration in the ordinary food products sold throughout the State, by an examination of the statistics presented in the foregoing table. The principal reason for this statement exists in the fact that the collections of samples are at present made chiefly from such articles as are most liable to adulteration.

Again, upon the appearance of a new form of adulteration it is customary to make special collections with reference to such articles, and in such cases it may happen that a very large percentage of such samples collected prove to be adulterated. An instance of this sort occurs in the present report under the division of drugs. A special collection was directed to be made of preparations sold under the name of sarsaparilla or extract of sarsaparilla. In the general classification the majority of these preparations were reckoned as adulterated samples, not because of any direct or definite violation of the statute in their sale, but in consequence of a violation of the apparent intent or spirit of the law, which demands that an article shall actually be what it is represented to be.

In the twenty-third annual report (1891) mention is made of a case of adulteration of canned peas with sulphate of copper. Complaint was made against a wholesale grocer who dealt largely in French peas, nearly all of which, as imported to the United States, are colored with copper. The complaint was brought in the municipal court in August, 1891, and the defendant was convicted, but appealed, and the case was tried in the superior court at Boston in February, 1892. The complaint was entered under three clauses of the general food and drug acts of 1882, which relate to food adulteration, — section 3, chapter 263, 1882 (*b*.) 6. and 7. which reads as follows: —

An article shall be deemed to be adulterated within the meaning of this act, —

(*b*.) 6. If it is colored, coated, polished or powdered, whereby damage is concealed, or if it is made to appear better or of greater value than it really is;

7. If it contains any added poisonous ingredient, or any ingredient which may render it injurious to the health of a person consuming it.

Much expert testimony was heard both on the part of the government and on that of the defendant, but the result of the case appeared to turn chiefly upon the question whether the coloring material (sulphate of copper or blue vitriol) was added for the purpose of preserving the natural green color of fresh peas, or of restoring the green color which they had lost in boiling (the actual term employed by the French to describe the process is "regreening," or, *reverdissage*). The subject is more fully treated by Dr. Worcester in his report, which follows. The outcome of this case was a disagreement of the jury, leaving the subject an open question, as it stood before.

Attention is also called to that portion of the analyst's report which treats of the common use of the word "compound" as a convenient method of evading the food and drug acts.

The following lists contain the names of cities and towns to which notices were sent in consequence of the adulterated samples of milk and other articles of food obtained in them.

The numbers of such notices which were sent are also specified.

The statistics relating to the samples of milk obtained in cities, which it has been customary to publish in this part of the report, may be found this year in the report of the analyst.

Cities and Towns to which Notices were sent on Account of Adulterated Milk.

Barre,	4	Hardwick,	1
Beverly,	1	Haverhill,	4
Boston,	11	Holden,	1
Brockton,	5	Holyoke,	3
Brookline,	1	Hull,	1
Cambridge,	20	Hyde Park,	7
Chelsea,	19	Lawrence,	2
Clinton,	2	Lowell,	4
Cottage City,	1	Lynn,	20
Dedham,	2	Malden,	3
Dover,	1	Marblehead,	5
Edgartown,	1	Marlborough,	4
Everett,	3	Millis,	2
Fall River,	30	Milton,	3
Fitchburg,	5	Natick,	2
Gloucester,	10	New Bedford,	2
Great Barrington,	1	Newton,	4

Cities and Towns to which Notices were sent on Account of Adulterated Milk — Concluded.

Plymouth,	1	Stoughton,	4
Provincetown,	8	Taunton,	1
Quincy,	2	Waltham,	8
Revere,	6	Ware,	2
Salem,	21	Acton,	1
Salisbury,	2	Westborough,	2
Somerville,	34	Winthrop,	1
Southborough,	1	Woburn,	7
Springfield,	3	Worcester,	12
Sterling,	1		
Stoneham,	3	Total,	305

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food other than Milk.

Amherst,	1	Newton,	1
Boston,	28	North Adams,	1
Brockton,	1	Revere,	3
Cambridge,	9	Springfield,	3
Chelsea,	4	Taunton,	4
Fall River,	5	Waltham,	2
Fitchburg,	2	Ware,	1
Holyoke,	9	Watertown,	1
Hyde Park,	2	Woburn,	4
Lowell,	3	Worcester,	2
Lynn,	1		
New Bedford,	12	Total,	100
Newburyport,	1		

The work of the analysts and inspectors of the Board performed under the provisions of the food and drug acts has been summarized and published each month in the regular bulletins issued by the Board. These bulletins contain a statement of the number of samples of food and drugs examined during the preceding month, the number found adulterated, the number of prosecutions conducted by the inspectors and the cities and towns visited by them for the purpose of inspection and collection of samples.

Special items of information are also presented, as occasion offers, in these bulletins. Comments were made during the year upon cases

differing from the ordinary methods of adulteration. One complaint was entered during the year for a sale of clam bouillon containing salicylic acid; another complaint had reference to the feeding of garbage to milch cows. Several complaints were made against parties selling cosmetics containing large quantities of irritant poisons. In all cases these were convicted. It is a question well worth considering whether the sale of such violent poisons as Madame Ruppert's and Madame Yale's complexion or face bleaches should not be controlled by statutes of a more exacting character than the present poison act.

During the past year, as in previous years, the Board has been occasionally called upon to investigate the character of milk as furnished directly from the producer at the dairy, and in one instance met with the most serious case of milk adulteration in its experience of the past ten years. The milk was obtained at the dairy of one Casey in Charlton, Worcester County, and the analysis of the milk of a dozen cans gave the following result: —

Sample.	Fat.	Total Solids.	Sample.	Fat.	Total Solids.
1, ...	2.44	6.53	7, ...	–	12.94
2, ...	1.56	6.32	8, . . .	2.07	8.92
3, ...	.61	5.49	9, ...	.88	6.97
4, ...	1.22	4.72	10, ...	.91	7.30
5, ...	2.57	7.69	11, ...	2.35	6.30
6, ...	1.49	5.41	12, ...	2.90	11.22

This analysis shows that the contents of these cans, which were prepared for delivery and sale, consisted of about one-half milk and one-half water, and in one instance the added water constituted about 65 per cent. of the contents of the can.

In the following brief table the ratio of adulteration found in articles of food and drugs in England and in Massachusetts, during the period of inspection and enforcement of the laws, is presented: —

Percentage of Adulteration as Given in the Reports of Each Year.

YEAR.	England and Wales.		Massachusetts.
	Ratio of Adulteration.	Average 5 years.	Ratio of Adulteration.
	Per Cent.	Per Cent.	Per Cent.
1877,	19.2		-
1878,	17.2		-
1879,	14.8	16.2	-
1880,	15.7		-
1881,	14.7		-
1882,	15.1		-
1883,	15.0		44.5
1884,	14.4	13.9	54.2
1885,	13.2		42.4
1886,	11.9		38.7
1887,	12.8		34.3
1888,	10.8		30.3
1889,	11.5	12.7	31.9
1890,	11.2		31.5
1891,	12.2		32.8

As a comment upon the foregoing table the following observations may be made: —

First. The gradual lessening of adulteration under the action of judicious legislation.

Second. The much greater ratio presented in the column headed Massachusetts than in that of England and Wales.

The reason for this great difference may be found, *first*, in the fact that in conformity to the requirements of the statutes in Massachusetts more than half the samples examined were milk. The standard of milk in this State is unusually high as compared with that of other countries (thirteen per cent. of solids, except in May

and June, when it is twelve per cent). In most European countries the usual standard is $11\frac{1}{2}$ per cent. of solids, and in no case more than 12. Hence it is the custom to report all samples as adulterated which are found to be below the foregoing limits. Now, there are many animals, especially those of the Holstein breed, which habitually produce milk having less than thirteen per cent. of solids. Hence it has not been deemed expedient to enter complaints at court to the full extent of the legal requirements. In the case of milk, therefore, the ratio of adulteration as reported is, to a considerable degree, an apparent and not an actual adulteration. *Secondly*, the samples selected under the Massachusetts law are mainly such as are known or suspected to be adulterated, while in England many samples of such staple articles as bread, flour, sugar and tea are annually examined, which are practically free from adulteration.

The ratio of samples of food collected for examination to the whole population for the past five years has been about as follows: In England and Wales, 1 to each 1,000 of the population; in the city of Paris, 1 to each 120 of the population; in Massachusetts, 1 to each 375 of the population.

Drugs.

In the inspection of drugs much of the work of collection and analysis has been, as usual, devoted to articles defined in the United States Pharmacopœia; the particulars of the examination will be found in Dr. Worcester's report.

The So-called Sarsaparilla Remedies.—In addition to the regular line of work, special attention was given during the year to certain empirical preparations sold under the general name of sarsaparilla, or extract of sarsaparilla. Judging from the lavish methods in which these preparations are everywhere advertised, — upon walls, fences, public buildings, railway lines, in the daily papers, in special broadside sheets, almanacs, pamphlets and other means, — and from the large amount sold in every city, town and village, a demand has been created for them, and a considerable proportion of the population uses them. As usual, the purchaser is induced to believe that every slight ailment is to be cured by sarsaparilla, and that systematic drugging with so-called spring medicines should be conducted every year for the alleged purpose of *purifying* the blood. If these empirical articles consisted of sarsaparilla only, undoubtedly there would be no cause for alarm, since sarsaparilla is

by no means an active remedy, and has no well-recognized therapeutic properties.

Headland says of it: "Sarsaparilla is a very doubtful hæmatic. It is thought by some to purify the blood. If it were so, we should have from the vegetable kingdom a distinct analogue to one of the mysterious mineral catalytics; but it is so rarely given without being combined with some more powerful agent, that it is difficult to judge whether or not it may have any striking virtues of its own."

Dr. Bolles says of it: "Although now it has been nearly discarded as a serious medicine by physicians, it is still a much-prized popular remedy. From the physiological action of this remedy little therapeutic value can be predicated, and it probably has not much." ("Reference Handbook of Medical Sciences," Vol. VI.)

Dr. Squire says of it: "Sarsaparilla has been vaunted as a remedy, and enjoys a high popular repute in this capacity; but it is quite inert." ("Reynold's System of Medicine," Vol. 5, p. 965.)

To what then, do these preparations of so-called sarsaparilla owe their action? On examination of a considerable number of samples made and sold by different manufacturers, it appears that with but few exceptions they contain a considerable percentage of a very active and powerful remedy, the iodide of potassium. This is a very valuable drug, when carefully and judiciously employed under the direction of a discreet and competent medical adviser, for certain special diseases. Like many other potent remedies, its action requires careful watching, lest the result of its use may defeat the desired object, and may prove actively harmful. The sale of such an article in unlimited quantities by druggists, grocers and others is censurable. More than this, the method of its sale is dishonest, since the unwary purchaser is led to believe that he is purchasing a harmless vegetable remedy, namely, sarsaparilla.

The sale of these preparations has reached far greater proportions in the United States than it has in any other country, and this result has been attained, not because of an actual need, but because of persistent and extensive advertising. The wise restrictions enforced in some foreign countries regarding the indiscriminate sale of such articles have very properly confined the traffic in them to very narrow limits. That the life of the general population has been prolonged, or the general health improved, by their use, as would appear from repeated statements, is not apparent. It may be seriously questioned whether the blood of persons who take iodide of potas-

sium continuously is not decidedly impoverished, instead of being purified, as is claimed by the manufacturers. It is not uncommon to find persons who have used continuously six, eight or ten pint bottles of one of these preparations.

Unlike sarsaparilla, the iodide of potassium is classed among poisons by nearly all writers upon toxicology, and in support of this statement the following extracts are presented from some of the most noted authorities upon the subject.

In commenting upon a so-called "blood purifier," an English proprietary medicine, Dr. Taylor, the eminent toxicologist, who examined it, found it to contain sixty-four grains of iodide of potassium in an eight-ounce mixture. The dose directed to be administered was one tablespoonful (half an ounce) four times a day. "Why such a mixture as this," says Dr. Taylor, "should be called a *blood mixture* and a *blood purifier* is incomprehensible. It has no more claim to this title than nitre, common salt, salammoniac, or other saline medicines which operate on and through the blood by absorption. Its properties (*i.e.*, those of iodide of potassium) are well known, and there is no novelty in its employment. The four doses directed to be taken daily represent sixteen grains, and if the person taking it is not under medical observation, such a daily quantity as this may accumulate in the system and do mischief. In some constitutions the iodide of potassium frequently taken proves specially injurious, — it produces iodism."

Another noted authority upon the effects of medicine, Dr. Sydney Ringer of London, says: "If its administration is continued for a long period, or if the patient manifests great susceptibility to its action, iodism is produced;" also that "this condition may arise after very small doses. The parts chiefly affected in iodism are the eyes, the nose, the mouth, the stomach and the bowels; there is also sometimes a distinct skin eruption. Inflammation of the mucous membrane covering the eyes, running at the nose, a form of salivation resembling that caused by mercury, purging and nausea, with loss of appetite, — all or some of these symptoms will then make their appearance."

"A grain, or even less," says Dr. Ringer, "may affect the stomach; moreover," he says, "iodide of potassium sometimes produces distressing depression of the mind and of the body. The patient becomes irritable, dejected, listless and wretched; exercise soon produces fatigue and perhaps fainting."

It follows from what has been said that iodide of potassium should never be given except in selected cases, and under the supervision of an experienced practitioner.

Dr. Taylor, in commenting upon this class of medicines further, says: "The sale of medicines of this kind should be strictly prohibited, unless the bottles containing them are issued with a caution label setting forth their true composition. It is only reasonable that a person should know what he is purchasing."

A law has been recently enacted in Italy in which such a requirement is provided.

Woodman and Tidy, in their work on "Forensic Medicine and Toxicology," present several cases of poisoning from the use of moderate doses of iodide of potassium, in one instance the amount being three grains only, three times a day.

Professor Curtis of New York, in the "Reference Handbook of Medical Sciences" (1887), describes the derangements constituting the condition known as *iodism* as follows: "The subject experiences the general feeling of discomfort preceding feverishness, and soon follow running at the nose and watering of the eyes, with frontal headache and sneezing. In sensitive persons the conjunctiva may be blood-shot, and the circumjacent tissues swollen and œdematous. A salty taste is perceived, and the salivary flow is somewhat freer than usual. From extension of the influence to the lower mucous membrane, there may next be cough, with hoarseness, from irritation of the throat; and epigastric sinking, with even nausea; and a watery diarrhœa, with colic, from affection of the gastro-intestinal tract. An eruption, like acne, is apt to break out, first upon the face, the papules being generally large and indurated, and later to appear upon parts of the trunk or extremities. Sometimes purpuric blotches have also appeared, or blebs, and sometimes the main eruption is eczematous instead of aceneform. Nervous symptoms are not so very uncommon, of the general type of listlessness and depression; and even in one case of long-continued heavy dosage Dr. H. C. Wood observed the subject to be 'intensely sleepy and stupid,' as in the allied condition of bromism."

An important point in connection with the phenomena of iodism is the very different susceptibility of different individuals, on the one hand, and of the same individuals at different times on the other.

Headland says of this drug: "Some systems are able to bear with impunity very large doses of iodide of potassium, others are readily affected by small quantities, and quickly experience the

symptoms of iodism. If the use of iodide be continued for some time, it has the effect of impoverishing the blood. It sometimes produces a vesicular eruption of the skin, and causes a degree of irritation of the mucous membrane of the nose and eyes, with some fever. Like all potent remedies, iodine requires to be carefully used. It is sufficient to give it in small doses. If given in large doses, and too long continued, it causes a deterioration of the blood, followed by an emaciation of the whole frame. So rigorously was this medicine used by the Swiss practitioners, after its first discovery, that serious consequences are said to have ensued in several cases. By these mishaps their faith in its utility was much shaken." ("Headland on the Action of Medicine," pp. 220, 398.)

With these facts in view, as supported by the statements of many of the first authorities, it is desirable that such remedies should be honestly marked with such labels as indicate their actual character, together with a caution as to the possible harm from their long-continued use.

During the ten years of work under the food and drug act the work of the State Board of Health in the inspection of drugs has not been confined to the remedies defined in the United States Pharmacopœia, but has embraced many other articles, and especially empirical preparations of a more or less harmful character.

Of the drugs found to be of a specially inferior quality during the earlier investigations of the analysts in 1883 and 1884, were the following: —

Tincture of opium (United States Pharmacopœia, 1.20 to 1.60 parts per 100 of morphine), 144 samples out of 197 fell below the required limit of 1.2, and some had as little as .01, .14, .17, or a mere fraction only of the minimum requirement. Citrate of iron and quinine (legal requirement 12 per cent. of quinine), 85 per cent. of the samples had less than the required amount, and several had as little as 3 and 3.5 per cent., or but little more than a quarter of the requirement. Of powdered jalap only 1 sample out of 12 conformed to the pharmacopœial standard. Of 192 samples of powdered drugs, 39 were found to be adulterated in various forms. Of 19 samples of compound spirits of ether, only 2 contained the required amount of the ethereal oil required by the statutes. Of 23 samples of spirit of nitrous ether, scarcely any had the required amount of ethyl nitrite.

Twenty-two samples or lots of the quinine pills made by different manufacturers were examined. These were examined in two groups, at an interval of several months, during which time the manufacturers had become aware of the work of the Board in this direction. The analysis of the second group showed in nearly every instance an improvement. The following figures indicate the percentages of the required weight of the pills made by nine manufacturers, in the two series of analyses: —

	First Series.	Second Series.		First Series.	Second Series.
1, ...	93.5	97.9	6, ...	84.7	89.5
2, ...	86.6	97.3	7, ...	93.8	101.1
3, ...	93.3	99.6	8, ...	104.4	100.5
4, ...	93.8	100.7	9, ...	97.0	97.1
5, ...	107.5	76.5			

The foregoing list shows an improvement in each case except two. Of 106 samples of pharmacopœial spirits and wines, only 10, or 9.4 per cent., conformed to the legal requirements.

In proof of the improvement under the action of the statutes, very marked changes for the better have been found to have taken place in many of the foregoing articles.

Among the non-pharmacopœial preparations examined in 1885 were 11 hair-dyes, all of which contained lead in large amounts; also 20 different fraudulent nostrums advertised for the cure of the opium-habit, most of which were solutions of morphine. One of them was the so-called "Keeley gold cure," which was found to contain no gold whatever. In 1887 about fifty proprietary articles, sold as tonics and bitters (some of which were advocated as temperance drinks), were examined chiefly for their alcoholic contents. All were found to contain alcohol in the proportion of 6 to 48 per cent. by volume. One of these, which was advertised as a remedy for inebriety and the opium-habit, was the celebrated "Scotch Oats Essence," containing alcohol and morphine, the latter in varying proportions. This nostrum very soon disappeared after its analysis had been published.

Cosmetics for the complexion, termed "face bleaches," "freckle lotions," "skin tonics," have been examined and found to consist of strong solutions of corrosive sublimate. It was required that these, if sold at all, should be labelled as poisons, and sold under careful restrictions only. Seventeen complaints were made against parties selling these articles in violation of the statutes.

Prosecutions.

The following is a condensed summary of the prosecutions conducted under the provisions of the food and drug acts, for the entire period since the enactment of the statutes of 1882 relating to that subject up to the date of this report (Sept. 30, 1892): —

Number of Complaints Entered in Court.

Year.	Food, not including Milk.	Drugs.	Milk.	Total.	Convictions.	Fines Imposed.
1883, . . .	–	5	4	9	8	–‡
1884, . . .	2	1	45	48	44	–‡
1885,* . .	50	1	68	119	103	–‡
1886,† . .	10	–	10	20	19	–‡
1887, . . .	30	–	34	64	60	–‡
1888, . . .	22	–	43	65	61	$2,042 00
1889, . . .	74	–	66	140	124	3,889 00
1890, . . .	78	–	24	102	96	3,919 00
1891, . . .	96	5	49	150	135	2,668 00
1892, . . .	52	12	72	136	123	3,661 70
Totals, .	414	24	415	853	773	$16,179 70

* To May 1, 1886. † Four months only. ‡ No record kept.

Ratio of convictions to complaints, 90.6 per cent.

Note. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

Under the provisions of chapter 289 of the Acts of 1884 the Board is required to report to the Legislature annually the number of prosecutions made under the food and drug acts, "and an itemized account of all money expended in carrying out the provisions thereof." Hence the Board transmitted the following report to the Legislature in February, 1892: —

OFFICE OF THE STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, February, 1893.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts, in General Court assembled.

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1892, was 136.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their result, are presented in the following table: —

MILK AND MILK PRODUCTS.

For Fraudulent Sales of Milk.

PLACE.	DATE.	RESULT.
In Lynn,	Oct. 21, 1891,	Convicted.
Lynn,	Oct. 21, 1891,	"
Fall River,	Nov. 5, 1891,	"
Fall River,	Nov. 12, 1891,	Discharged.
Fall River,	Dec. 10, 1891,	Convicted.
Fall River,	Mar. 23, 1892,	"
Fall River,*	Mar. 23, 1892,	"
Fall River,*	Mar. 23, 1892,	"
Fall River,*	Mar. 23, 1892,	Discharged.
Fall River,	Mar. 23, 1892,	Convicted.
Fall River,†	Mar. 23, 1892,	"
Fall River,	Mar. 23, 1892,	"
Fall River,	Apr. 6, 1892,	"
Fall River,	May 6, 1892,	"
Fall River,‡	Sept. 27, 1892,	"

* Swansea. † Tiverton, R. I. ‡ Westport.

For Fraudulent Sales of Milk — Continued.

Place.	Date.	Result.
In Fall River, ...	Sept. 27, 1892, . .	Convicted.
Fitchburg, ...	Dec. 21, 1891, . .	"
Worcester, ...	Mar. 15, 1892, . .	"
Salem, ...	July 25, 1892, . .	Discharged.
Salem, ...	July 25, 1892, . .	Convicted.
Salem, ...	July 25, 1892, . .	"
West Medway, . . .	Oct. 30, 1891, . .	"
Weston, ...	Oct. 28, 1891, . .	"
Holden, ...	Nov. 12, 1891, . .	"
Billerica, ...	Dec. 1, 1891, . .	"
Billerica, ...	Dec. 1, 1891, . .	"
Essex, ...	Dec. 17, 1891, . .	"
Sterling, ...	Jan. 9, 1892, . .	"
North Adams, . . .	Feb. 13, 1892, . .	"
Revere, ...	April 12, 1892, . .	"
Revere, ...	July 13, 1892, . .	"
Revere, ...	July 13, 1892, . .	"
Revere, ...	July 13, 1892, . .	"
Dracut, ...	April 9, 1892, . .	"
Dracut, ...	April 9, 1892, . .	"
Dracut, ...	April 9, 1892, . .	"
Dracut, ...	Aug. 13, 1892, . .	"
Brookfield, ...	April 2, 1892, . .	"
Bedford, ...	May 17, 1892, . .	"
Weston, ...	May 28, 1892, . .	Discharged.
Dunstable, ...	Nov. – 1891, . .	Convicted.
Westfield, ...	June 14, 1892, . .	"
Winthrop, ...	July 23, 1892, . .	"
Stoneham, ...	July 19, 1892, . .	"
Nahant, ...	July 12, 1892, . .	"
Nahant, ...	July 12, 1892, . .	"
Nahant, ...	July 12, 1892, . .	"
Nahant, ...	July 12, 1892, . .	"
Nahant, ...	July 12, 1892, . .	"
Upton, ...	Aug. 24, 1892, . .	"
Waltham, ...	Aug. 27, 1892, . .	"
Nantucket, . . .	Aug. 9, 1892, . .	"
Nantucket, . . .	Aug. 9, 1892, . .	"
Cottage City, . . .	Aug. 19, 1892, . .	"
Cottage City, . . .	Aug. 19, 1892, . .	"
Cottage City, . . .	Aug. 19, 1892, . .	Discharged.

For Fraudulent Sales of Milk — Concluded.

Place.	Date.	Result.
In Edgartown,	Aug. 25, 1892,	Convicted.
Edgartown,	Aug. 25, 1892,	Discharged.
Millis,	Sept. 24, 1892,	Convicted.

Total, 59 cases.

For Feeding Offal to Cows.

In Dracut,	May 7, 1892,	Discharged.
Dracut,	May 7, 1892,	"
Dracut,	May 7, 1892,	Nol. pros.

Total, 3 cases.

For Fraudulent Sales of Butter. (Oleomargarine.)

In Boston,	Nov. 14, 1891,	Convicted.
Boston,	March 5, 1892,	"
Fall River,	Nov. 25, 1891,	"
Fall River,	Dec. 2, 1891,	"
Fall River,	Dec. 10, 1891,	"
Fall River,	March 23, 1892,	"
New Bedford,	Dec. 26, 1891,	"
New Bedford,	Dec. 31, 1891,	"
Marlborough,	Dec. 5, 1891,	"
Somerville,	March 2, 1892,	Discharged.
Somerville,	June 21, 1892,	Convicted.

Total, 11 cases.

Other Articles of Food.

Honey.

In Boston,	Oct. 26, 1891,	Convicted.
Boston,	Dec. 30, 1891,	"
Hyde Park,	Nov. 6, 1891,	"
Ware,	Dec. 18, 1891,	"
North Adams,	Feb. 7, 1892,	"
Chicopee,	Mar. 31, 1892,	"
Lynn,	Mar. 26, 1892,	"
Lowell,	April 16, 1892,	Discharged.

Coffee.

In Westfield,	Oct. 3, 1891,	Convicted.
Fall River,	Nov. 21, 1891,	"

Coffee — Concluded.

Place.	Date.	Result.
In New Bedford, . . .	Dec. 26, 1891, . .	Convicted.
Fitchburg, ...	Dec. 21, 1891, . .	Discharged.
Northampton, . . .	April 9, 1892, . .	Convicted.
Worcester, . . .	April 4, 1892, . .	"

Maple Syrup.

In Lowell, ...	Feb. 11, 1892, . .	Convicted.

Cream of Tartar.

In Marlborough, . . .	Dec. 5, 1891, . .	Convicted.
New Bedford, . . .	Dec. 26, 1891, . .	"
New Bedford, . . .	Dec. 26, 1891, . .	"
Springfield, . . .	Dec. 19, 1891, . .	"
Northampton, . . .	April 9, 1892, . .	"
Worcester, . . .	April 4, 1892, . .	"
North Adams, . . .	Jan. 5, 1892, . .	"

Mustard.

In Boston, ...	Dec. 19, 1891, . .	Convicted.
Boston, ...	Aug. 19, 1892, . .	"
Boston, ...	Aug. 20, 1892, . .	"
Chelsea, ...	Aug. 23, 1892, . .	"
New Bedford, . . .	Jan. 16, 1892, . .	"
Worcester, . . .	April 4, 1892, . .	"
Ware, ...	Dec. 18, 1891, . .	"
Ware, ...	Jan. 22, 1892, . .	"

Pepper.

In Boston, ...	Dec. 19, 1891, . .	Convicted.
Boston, ...	Aug. 19, 1892, . .	"
Boston, ...	Aug. 20, 1892, . .	"
Chelsea, ...	Aug. 23, 1892, . .	"
New Bedford, . . .	Jan. 16, 1892, . .	"
Springfield, . . .	Dec. 19, 1891, . .	"
North Adams, . . .	Jan. 5, 1892, . .	"
North Adams, . . .	Feb. 7, 1892, . .	"

Cloves.

In Springfield, . . .	Dec. 19, 1891, . .	Convicted.
North Adams, . . .	Feb. 7, 1892, . .	"

Cinnamon and Cassia.

Place.	Date.	Result.
In Boston,	Dec. 19, 1891,	Convicted.
Boston,	Aug. 19, 1892,	"
Boston,	Aug. 20, 1892,	"
Chelsea,	Aug. 23, 1892,	"

Ginger.

In Boston,	Dec. 19, 1891,	Convicted.

Molasses.

In North Adams,	Feb. 7, 1892,	Convicted.

Clam Bouillon.

In Fall River,	May 26, 1892,	Convicted.

French Peas.

In Fall River,	April 29, 1892,	Convicted.

Confectionery.

In Boston,	Nov. 3, 1891,	Convicted.
Boston,	Nov. 3, 1891,	"

Total, 50 cases.

Drugs and Cosmetics.

In Lowell,	Jan. 2, 1892,	Oriental Cream,	Convicted.
Boston,	April 20, 1892,	Face Bleach,	"
New Bedford,	July 19, 1892,	Face Bleach,	"
New Bedford,	Sept. 8, 1892,	Soule's Eradicator,	"
Fall River,	July 20, 1892,	Face Bleach,	"
Fall River,	Aug. 3, 1892,	Freckle Lotion,	"
Fall River,	Aug. 17, 1892,	Soule's Eradicator,	"
Fall River,	Aug. 17, 1892,	Freckle Lotion,	"
Nantucket,	Aug. 9, 1892,	Soule's Eradicator,	"
Nantucket,	Aug. 9, 1892,	Freckle Lotion,	"
Cottage City,	Aug. 19, 1892,	Soule's Eradicator,	"
Cottage City,	Aug. 19, 1892,	Soule's Eradicator,	"

Total, 12 cases.

Summary.

Milk and milk products,	73 cases.
Other articles of food,	50 "
Drugs and cosmetics,	12 "
Total,	135 cases.

Summary.

The whole number of complaints entered by the State Board of Health in the courts of the Commonwealth against parties for violation of the acts relating to food and drug inspection was 135. In 123, or 91 per cent. of these, the parties were convicted. Twelve were discharged, either in the lower or in the upper courts.

Of the foregoing cases, 59 were for violation of the laws relating to milk adulteration, of which number 50 resulted in conviction. Three of this number were for violation of the statute forbidding the feeding of garbage or offal to milch cows. (Chapter 326 of the Acts of 1889.) These, together with other cases entered by the local milk inspector, were the first complaints in the State under this statute. Evidence was introduced that such offal was found in the cribs where the cows were fed, but the defendants claiming that it was there accidentally, they were discharged.

Eleven complaints were introduced under the oleomargarine laws, and convictions secured in all except one.

There were also fifty complaints for fraudulent sales of other kinds of food, in all of which except two the parties were convicted.

The articles of food embraced in the foregoing list were the following: —

Honey, 8 cases; coffee, 6; maple syrup, 1; cream of tartar, 7; mustard, 8; pepper, 8; cloves, 2; cinnamon and cassia, 4; ginger, 1; molasses, 1; clam bouillon, 1; French peas, 1; confectionery, 2.

In the case of a complaint entered and referred to in the report of the preceding year, for selling French peas colored with sulphate of copper (blue vitriol), wherein the defendant was convicted in the lower court, but appealed, the case was afterward tried in the superior court in January, 1892, and after a lengthy trial, in which many experts were examined, the jury disagreed, and the question so far as it relates to this case still remains undecided.

All of the complaints referred to under the head of drugs were for sales of poisonous cosmetics, the chief and very poisonous ingredient being corrosive sublimate. In order to increase their sale, these dangerous preparations are often marked as harmless. In all of the complaints entered the parties were convicted under the law requiring a poison label to be attached to each package, and a registry to be made. (Chapter 209 of the Acts of 1888.)

The standard of whole milk in Massachusetts is 13 per cent. of solid residue, except in the months of May and June, when it is 12

per cent. The following list presents the total solids in all of the samples of milk upon which complaints in court were founded, so far as records of the same were kept: —

7.78	10.10	10.71	11.10	11.48
8.35	10.13	10.74	11.10	11.53
8.83	10.14	10.76	11.11	11.53
9.16	10.24	10.80	11.15	11.57
9.81	10.25	10.83	11.16	11.60
9.94	10.28	10.93	11.17	11.63
9.97	10.29	10.96	11.21	11.64
10.03	10.40	10.97	11.24	11.78
10.04	10.43	10.99	11.28	11.80
10.08	10.44	11.93	11.33	
10.08	10.68	11.07	11.37	
10.10	10.71	11.10	11.45	

Average, ... 10.68.

The total number of samples of food and drugs examined during the year was as follows: —

Milk, ...	3,264
Other articles of food, ...	2,441
Drugs, ...	487
Total, ...	6,192

Total expenses of collection, examination and prosecution, ...	$11,180 30
Average expense per sample collected, ...	1 81

Fines.

The amount of the fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows: —

Fines paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1892.

Under the provisions of the laws relating to milk and milk products, ...	$2,689 00
Under the provisions of laws relative to other articles of food,	799 70
Under the provisions of laws relative to drugs, ...	173 00
Total, ...	$3,661 70

Expenditures

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1892.

	For the Enforcement of the Statutes relating to Food and Drug Inspection.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts,	$2,500 00	$1,630 00
Salaries of inspectors,	2,325 00	1,533 34
Travelling expenses and purchase of samples,	1,200 00	782 95
Apparatus,	458 76	305 85
Rent at Harvard Medical School,	180 00	120 00
Chemical analysis,*	–	63 00
Furniture and fittings at new laboratory,	25 77	17 18
Legal services,	–	35 00
Printing,	3 45	–
	$6,692 98	$4,487 32
		6,692 98
Total,	. . .	$11,180 30

* The extra expense for chemical analyses was incurred in cases where the results of the analyses of the Board's chemists were disputed, and requests were made to submit the samples to other chemists.

SAM'L W. ABBOTT,

Secretary.

REPORT OF DR. C. P. WORCESTER, ANALYST.

Dr. S. W. Abbott, *Secretary of the State Board of Health.*

Dear Sir: — I have the honor to present my report on the analysis of food and drugs for the year beginning Oct. 1, 1891, and ending Sept. 30, 1892.

The Laboratory.

Previous to Oct. 1, 1891, the work of food and drug analysis had been done by a number of chemists in as many private laboratories. At the beginning of the year here reported the Board secured a laboratory for itself, and there placed all the analytical work, with the exception of a portion of the milk analysis, in charge of one chemist.

The laboratory which was first secured was a small room in the Harvard Medical School, 688 Boylston Street, Boston. This was the only available room in that building, but it proved too small and too dark to be well adapted for the work. Accordingly on June 1 a much larger room was provided in the Grace building, 994 Washington Street, in which the work has been carried on since that time. This room, having eight large windows on the south and west, makes an excellent laboratory.

During the first half of the year Mr. Harris E. Sawyer, A.B., assisted in the work of the laboratory; during the latter half Mr. Albert E. Leach, S.B., has been my associate.

The Laboratory Equipment.

The apparatus of most value which has been purchased for the laboratory is a Schmidt & Haensch polariscope, imported for the Board, and a pair of short-beam Trœmner chemical balances. The minor apparatus includes thirty-four platinum dishes of an average weight of 17 grammes, rough scales, three copper water baths, benches and tables (one topped with glazed tiles), Bunsen and incandescent burners, small wooden hood lined with asbestos, cases of drawers and enclosed shelves, etc. We have the usual assort-

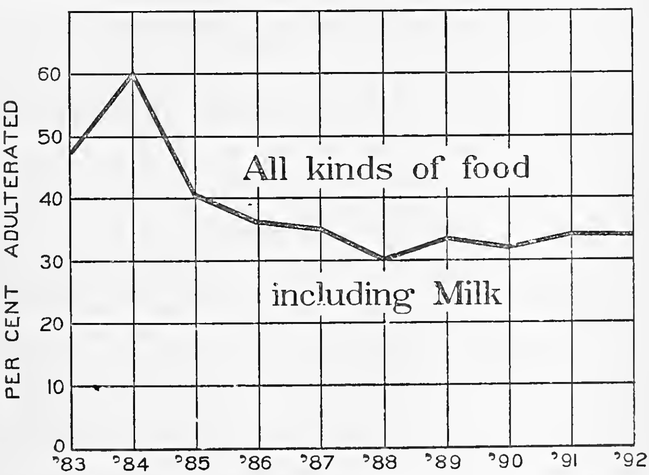
ment of chemical glass, porcelain and hardware, and the ordinary chemical supplies.

THE WORK OF THE LABORATORY.

The three inspectors of the Board bring in from practically all quarters of the State samples of food and drugs which they have purchased in the open market. Each inspector has a cupboard under lock and key in which he deposits his samples. These cupboards, which the inspectors open from outside the laboratory, also open by a second door into the laboratory. This device we have found of practical value in establishing the fact in court that a certain sample passed directly from the charge of the inspector to that of the analyst.

ANALYSIS OF FOODS.

CHART I. — *Showing the Percentage of Adulterated Samples of All Foods and Milk examined during the Ten Years ending Sept. 30, 1892.*



YEARS.	Per Cent. of Adulteration.	YEARS.	Per Cent. of Adulteration.
1883, ...	47.6	1888, ...	30.6
1884, ...	60.4	1889, ...	33.8
1885, ...	40.9	1890, ...	32.3
1886, ...	36.3	1891, ...	34.1
1887, ...	35.2	1892, ...	34.0

In reporting the percentage of adulteration of the samples of foods submitted for analysis it must be remarked that for various reasons

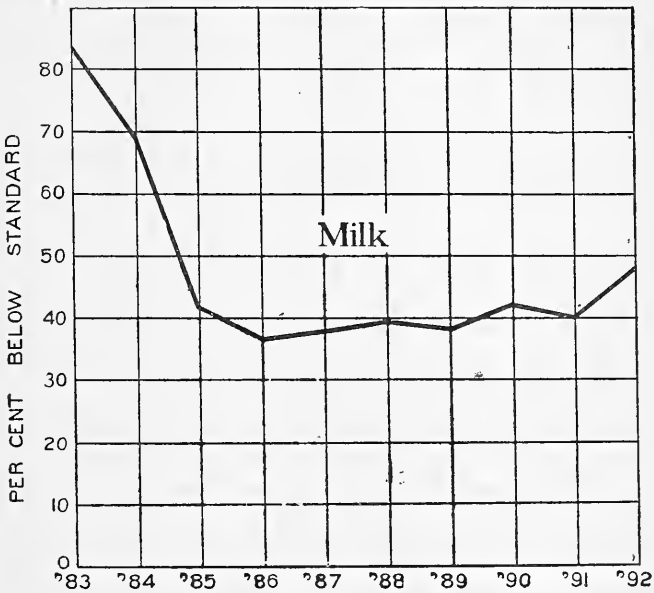
the figures do not indicate the percentage of adulteration of food in general throughout the State, because only such varieties as are liable to adulteration are inspected, and also in a large number of instances samples are taken only from suspected brands, or from supplies which have been reported unsatisfactory. Thus it will be seen that the actual adulteration of food would be represented by a curve much nearer the zero line than such as appears in Chart I.

Milk.

More samples of milk are brought to us than of all other foods combined. Our method of analysis does not differ from that employed by the analysts of the Board in years past. None of the samples are subjected to a preliminary inspection by the lactometer and lactoscope, but the total solids are determined in every case. The fat is estimated in the case of such samples only as fall below the standard in total solids. The method of determining the fat by extraction with benzine proves a ready way of getting at the approximate percentage. With our present facilities, by employing a preliminary inspection, we could efficiently test many more samples annually than we have done.

The percentage of samples of milk found to be below the standard is higher than that of any of the other foods. This is due to a variety of causes, among which may be noted: (1) the ease with which this food can be adulterated by watering or skimming; (2) the neglect on the part of small dealers to mix their milk. By attending to this simple precaution, the farmer whose cows give milk on both sides of the legal standard may send to market a uniformly good milk, and will run no risk of being caught "with milk in his possession of less than standard quality." By neglecting the precaution of mixing his milk every time a pint is drawn, the restaurant keeper also runs the risk of unintentionally selling for milk both cream and skimmed milk from the same can. It has often appeared in court that the offence of the dealer was pure carelessness in this particular.

Chart II. — *Showing the Percentage of Adulterated Samples of Milk examined during the Ten Years ending Sept. 30, 1892.*



Years.	Per Cent. of Adultera-tion.	Years.	Per Cent. of Adultera-tion.
1883, ...	83.5	1888, ...	39.5
1884, ...	9.0	1889, ...	38.6
1885, ...	41.7	1890, ...	42.7
1886, ...	36.8	1891, ...	40.3
1887, ...	38.3	1892, ...	48.2

Chart II., illustrating the adulteration of milk during the last decade, shows that the quality rapidly improved during the years 1883, 1884 and 1885, but since that time what little change has taken place appears to have been in the wrong direction. An explanation of this may be found in the fact that of late, suspected producers have received increased attention. If the samples coming from this class are omitted, the percentage of adulteration is more uniform. Furthermore, the milk records of previous years have been improved by the addition of many samples of known purity, while last year's average has received no such help.

But very few cases of colored milk were found. The color used

was annatto. Boracic acid as a preservative was found in two instances.

In general the quality of the milk in smaller towns is superior to that in the cities.

The following tables contain a summary of the statistics relative to the milk obtained through the State, with the exception of the four western counties : —

MILK FROM CITIES.

Cities.	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. of Adultera-tion.	Lowest Sample.	Number of Skimmed Milks.
Boston,	267	141	126	47.2	10.34	1
Brockton,	48	36	12	25.0	10.70	-
Cambridge,	175	89	86	49.2	8.95	1
Chelsea,	155	72	83	53.5	10.83	2
Fall River,	299	170	129	43.2	9.44	1
Fitchburg,	40	19	21	52.5	10.20	-
Gloucester,	85	46	39	45.8	8.70	-
Haverhill,	36	18	18	50.0	11.77	-
Lawrence,	45	31	14	31.1	11.47	1
Lowell,	47	18	29	61.7	10.36	1
Lynn,	103	55	48	46.6	10.91	4
Malden,	17	10	7	41.2	11.11	-
Marlborough,	79	47	32	40.5	9.60	2
Newton,	84	60	24	28.5	11.22	1
New Bedford,	48	18	30	62.3	10.30	-
Newburyport,	24	15	9	37.5	11.68	-
Quincy,	35	17	18	51.4	10.60	-
Salem,	149	80	69	46.3	9.88	-
Somerville,	135	47	88	65.2	9.67	-
Taunton,	36	31	5	13.9	11.70	-
Waltham,	55	29	26	47.2	10.61	-
Woburn,	42	24	18	42.8	10.41	-
Worcester,	151	71	80	52.9	9.81	-
	2,155	1,144	1,011	46.9	8.70	14

MILK FROM TOWNS.

TOWNS.	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. of Adultera-tion.	Lowest Sample.	Number of Skimmed Milks.
Adams,	14	9	5	35.7	10.00	-
Beverly,	12	9	3	25.	11.37	-
Brookline,	96	67	29	30.2	10.84	1
Clinton,	12	9	3	25.	11.24	-
Cottage City,	10	4	6	60.	8.35	-
Danvers,	9	5	4	44.4	9.86	-
Dedham,	15	11	4	26.6	11.26	-
Edgartown,	12	5	7	58.3	11.24	-
Everett,	12	2	10	83.3	9.97	-
Framingham,	18	14	4	22.2	12.09	-
Hull,	12	6	6	50.	10.92	-
Hyde Park,	71	30	41	57.7	10.40	-
Medford,	5	4	1	20.	11.90	-
Melrose,	7	7	0	0.	12.01	-
Nahant,	7	2	5	71.4	9.97	-
Nantucket,	12	3	9	75.0	11.10	-
Natick,	34	13	21	61.8	10.15	2
Plymouth,	24	23	1	4.1	11.53	-
Provincetown,	21	9	12	57.1	10.74	-
Randolph,	12	7	5	41.6	12.50	-
Reading,	5	1	4	80.0	11.88	-
Revere,	43	20	23	53.5	10.04	-
Southborough,	8	3	5	62.5	10.78	-
Stoneham,	7	4	3	42.8	10.43	-
Stoughton,	21	10	11	52.3	11.25	-
Watertown,	5	2	3	60.0	12.80	-
Westborough,	23	16	7	30.4	11.81	1
Weymouth,	6	3	3	50.	12.50	-
Winchester,	4	4	0	0.	12.30	-
Winthrop,	18	8	10	55.5	11.48	-
	555	310	245	44.1	8.35	4

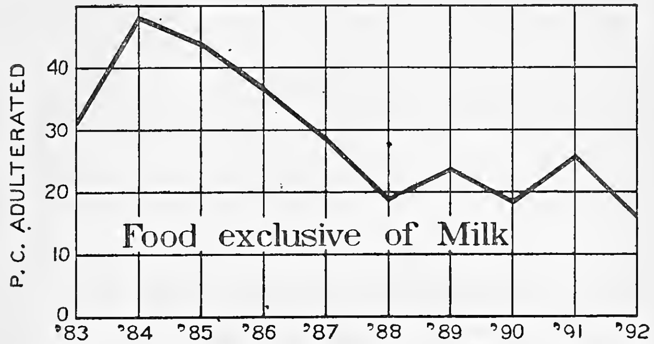
Milk from Suspected Producers.

Suspected Producers.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. of Adulteration.	Lowest Sample.
Acton, ...	7	1	6	85.7	10.51
Barre, ...	15	0	15	100.	11.62
Bedford, ...	8	1	7	87.5	12.37
Billerica, ...	12	6	6	50.0	11.78
Bolton, ...	12	2	10	83.3	9.00
Chelmsford, ...	15	7	8	53.3	12.56
Dover, ...	10	9	1	10.0	11.20
Dracut, ...	17	4	13	76.4	10.71
Hardwick, ...	8	0	8	100.0	11.35
Holden, ...	9	1	8	88.8	10.99
Holliston, ...	2	0	2	100.0	11.89
Hopkinton, ...	12	4	8	66.6	12.46
Lincoln, ...	5	2	3	60.0	11.44
Medway, ...	14	7	7	50.0	11.84
Millis, ...	12	5	7	58.3	10.03
Milton, ...	12	4	8	66.6	11.46
Needham, ...	2	2	0	0.0	13.63
Northborough, ...	3	0	3	100.0	12.12
Shrewsbury, ...	2	0	2	100.0	11.70
Sterling, ...	15	1	14	93.3	10.90
Upton, ...	9	2	7	77.7	8.83
Waltham, ...	12	6	6	50.0	11.77
Warren, ...	15	7	8	53.3	10.80
Wayland, ...	10	2	8	80.0	11.50
Westborough, ...	14	1	13	92.9	11.07
Weston, ...	6	2	4	66.6	12.00
Wrentham, ...	3	0	3	100.0	11.57
	261	76	185	70.9	8.83

Summary of the Three Foregoing Tables.

	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. of Adulteration.	Lowest Sample.
Cities, ...	2,155	1,144	1,011	46.9	8.70
Towns, ...	555	310	245	44.1	8.35
Suspected producers, ...	261	76	185	70.9	8.83
Miscellaneous, ...	48	25	23	47.9	-
Total Milks, ...	3,019	1,555	1,464	48.4	-

CHART III. — *Showing the Percentage of Adulterated Samples of Food, Exclusive of Milk, examined during the Ten Years ending Sept. 30, 1892.*



YEARS.	Per Cent. of Adulteration.	YEARS.	Per Cent. of Adulteration.
1883, ...	31.6	1888, ...	19.2
1884, ...	48.4	1889, ...	23.9
1885, ...	44.0	1890, ...	18.7
1886, ...	37.0	1891, ...	26.1
1887, ...	29.0	1892, ...	16.5

Butter.

The only adulteration which has been found in this food is the substitution of oleomargarine. The percentage of adulteration (17.5) represents simply the ratio of samples of oleomargarine to those of genuine butter (61 to 287). Of these samples, many were known by the inspectors to be oleomargarine, but were sold from improperly marked tubs or in an illegal wrapper. Very few were samples of oleomargarine fraudulently substituted for butter.

Our method of analysis of butter is the same as that described in previous reports, — essentially the Reichert process, by which the volatile acids of the fat are determined. In practice we have found that after the sample of butter has been melted it has been in every case possible to foretell the result of the analysis from the odor. The oleomargarine is distinguished by a peculiar, slightly flat, fatty odor, and by the absence of the distinctly pleasant odor of genuine melted butter.

Cheese.

The analysis of cheese is not a satisfactory undertaking in this State, because there is no legal standard, as there is in many other States. Since the manufacturer may without risk sell cheese without its proper percentage of fat, there is no inducement for him to

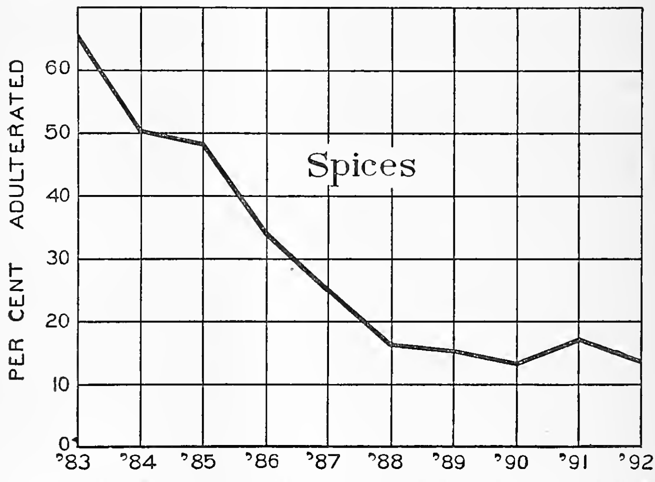
supply the missing cream by substituting cheaper fats. If a legal standard should be established, without doubt much adulteration would be discovered, and the quality of cheese sold in the State would be improved.

All of the samples submitted were found to be genuine cheese of various qualities.

Spices.

As is generally recognized, ground spices are more subject to intentional adulteration than any other foods. The mixtures of ground trash which are added to or substituted for genuine ground spice are rarely such poor imitations as to attract attention, and usually the mixture is so skilfully compounded that its fraudulent nature cannot be detected by any less elaborate means than a chemical or microscopic examination. The curve showing the adulteration of spices during the ten years of the inspection by the Board

CHART IV. — *Showing the Percentage of Adulterated Samples of Spices examined during the Ten Years ending Sept. 30, 1892.*



Years.	Per Cent. of Adulteration.	Years.	Per Cent. of Adulteration.
1883, ...	65.3	1888, ...	16.5
1884, ...	50.3	1889, ...	15.4
1885, ...	48.3	1890, ...	13.3
1886, ...	34.0	1891, ...	17.3
1887, ...	25.1	1892, ...	13.6

indicates a nearly uniform decrease in adulteration. The number of spices examined during the last year was nearly a thousand, — so large a number that any insignificant or chance variation from

the average quality could have no undue weight. The diagram fairly represents the purity of the ground spices on sale in bulk in the poorer class grocery stores of the State. The percentage of adulteration is, however, somewhat increased by the addition of samples of "*compounds*" not properly marked, and of suspected brands of package spices.

The analysis of spices has been wholly by means of the microscope, except in cases in which a determination of the ash was made to confirm the presence of sand. The accompanying plates (I.–V.) illustrate the microscopic distinction between the genuine spices in a few instances and some typically adulterated specimens.

Compounds.

It is expressly provided in the Statutes of 1884, chapter 289, section 5, that the law against the adulteration of food "shall not apply to mixtures or compounds recognized as ordinary articles of food or drinks, provided that the same are not injurious to health, and are distinctly labelled as mixtures or compounds." Under cover of this provision of the law, some of the worst cases of fraudulent adulteration are protected. There have been found very many attempts to evade even this law, by making the "compound" label as inconspicuous or as ambiguous as possible. A well-known brand is "a pure mustard compound." Others are "pure goods, compounded for family or medicinal use." Many others bear the word "compound" so illegibly printed as to be a violation of the statute, while at the same time they make possible the excuse of accidental illegibility. It is always an open question whether or not such labels properly conform to the statute requiring that they be "*distinctly* labelled mixtures or compounds." Some courts have held that they do, and others have denied it; but leaving out of consideration such attempts to evade this requirement, it may properly be asked, does not the law by this "compound" exception practically connive at fraud?

In a flourishing grocery store in a poorer quarter of Boston I heard one day a customer ask for a quarter of a pound of ginger. A package was handed down, bearing the distinct label "Compound Ginger." I bought a similar package, and its microscopic appearance is shown in Fig. 15. It consisted chiefly of corn, wheat and sawdust. The only part that was of value to the customer was of course the small amount of genuine ginger that the package contained. The other ingredients were added solely for stuffing, to deceive the customer

into the belief that she was getting a quarter of a pound of ginger. If the grocer had weighed out half an ounce of ginger and then had added enough whole corn, wheat and pine chips to turn the scales at a quarter of a pound, the customer would have seen and remonstrated at an obvious fraud. Is not the fraud quite as offensive when concealed? The statute provides that the adulterated article "shall be labelled mixture or compound." It is worth noticing, that the word "compound" is almost invariably selected by the dealer rather than "mixture." "Mixture" is too plain a word for his purpose. It suggests to the uninitiated at once that the pure material may be mixed *with* something cheaper. But if "compound" conveys any meaning at all to the average customer, it vaguely suggests a reference to some technical process of preparation. It is often used on the label as synonymous with *ground*, as "compounded for family use;" or for "preparation," as "warranted the finest compound."

These considerations point to the conclusions that it is an object to the dealer to employ as much deception as the law allows, and that the compound law allows a good deal of deception. It is often urged that there really is no fraud in selling "compound" foods, since the price of the compound is reduced in proportion to its adulteration. This is by no means always true. The real question, however, is whether it is right to allow the sale of adulterated food. The compound exception to the pure food law practically legalizes adulteration.

The spice dealers are the chief ones to avail themselves of the compound law, but samples of compound coffee, honey, lard, etc., are often found.

Allspice (Pimento).

This variety of spice is less subject to adulteration than others, perhaps because of its cheapness, and also because it is very generally sold to the small dealers whole, and ground in the store.

The adulterants found were ginger, wheat, nutmeg and cassia. Ratio of adulterated samples, 3 per cent.

Cassia.

The adulterants found were wheat, ginger, nut shells, pepper and turmeric. Ratio of adulterated samples, 8 per cent.

Cayenne.

The favorite adulterant is corn. Many samples are found full of loosely cohering lumps easily broken in the fingers. The microscope shows that this lumping is due to a vigorous growth of a mould,

which often is as bulky as the spice itself. Fig. 13 shows a typically adulterated specimen, Fig. 12 being the genuine cayenne.

Adulterants found were corn, ginger, wheat, nut shells and turmeric. Ratio of adulterated samples, 28 per cent.

Cloves.

The strength of this spice varies greatly, according to the amount of the volatile oil present. The ground spice, unless kept in tight packages, constantly loses its strength. Fig. 17 shows a bit of freshly ground cloves surrounded by droplets of the oil. None of the samples of ground cloves showed anything like as much oil as is here shown. In some cases the oil is without doubt intentionally extracted after grinding.

Adulterants found were wheat, corn, ginger, clove stems and nut shells. Ratio of adulteration, 9 per cent.

Ginger.

Ginger is comparatively free from adulteration. The ground manilla rope which is reputed to be a common adulterant has not appeared in any samples examined.

Adulterants found were wheat, corn, turmeric, rice and sawdust. Ratio of adulteration, 4 per cent.

Mace.

No samples of adulterated mace have been found. The only sophistication seems to be the substitution of inferior grades.

Mustard.

Mustard easily leads the spices in adulteration. The standard of purity of mustard has been defined as the pure seed ground and sifted from its hulls.* This standard has been modified recently so as to admit the extraction of the fixed oil, which is of little value, and whose presence prevents the mustard from keeping well. Fig. 5 shows the appearance of the genuine ground seed before the extraction of the oil.

Few samples of the pure ground seeds have been found in the market whose oil has not been extracted.

There seems to be a popular impression that mustard must be diluted with flour or some such inert material (adulterant) to be properly prepared. If such dilution is needed, it can be readily and cheaply done by the consumer. Some of the highest priced of English mustards are adulterated to the extent of 50 per cent. or more.

* "Food Adulteration and its Detection:" Battershall.

Genuine mustard is of a pale, yellowish-gray color, but many dealers have an impression that the public demand something bright colored. Hence the so general addition of ground turmeric root. The resulting compound is often of a startling buttercup-yellow color.

Adulterants found were wheat, rice, turmeric, cayenne and mustard hulls. Ratio of adulteration, 30 per cent.

Nutmeg.

But three samples were examined, so that the ratio of adulteration may not be typical. Two were found genuine, and one adulterated with wheat.

Pepper.

The adulterators' skill finds a profitable field in the imitation of ground pepper. Ground black pepper consists of white and black particles, easily distinguished, but too small for their nature to be readily determined without a microscope. The list of materials used as adulterants is almost unlimited. Those found in samples here reported were wheat, buckwheat, corn, ginger, cayenne, sawdust, charcoal, pepper dust and undefined dirt. Of these, buckwheat seems to be the one best adapted by nature for the purpose. Not only does the gross appearance of the ground grain resemble pepper, but the microscope shows starch aggregations quite similar to those of pepper. Figs. 8 to 11 show pepper typically adulterated.

Tea.

No case of the fraudulent adulteration of tea with other leaves has been found. In five instances the tea was of so poor a quality as to deserve notice. In these cases, whether caused by a previous steeping or by the addition of sand and dirt, the percentage of inorganic matter was in excess.

The method of examination consists in the determination of the weight of the ash, and in the examination of the wetted leaves.

Percentage of bad samples, 5.

Coffee.

The adulteration of coffee, judging from the 92 samples here reported, has not yet received a serious check.

The adulterants found were roasted peas, beans, wheat, rye, chicory, brown bread, corn, charcoal and red slate. Chicory and cereals may usually be separated from the genuine coffee by their sinking in cold water. Ratio of adulteration, 35 per cent.

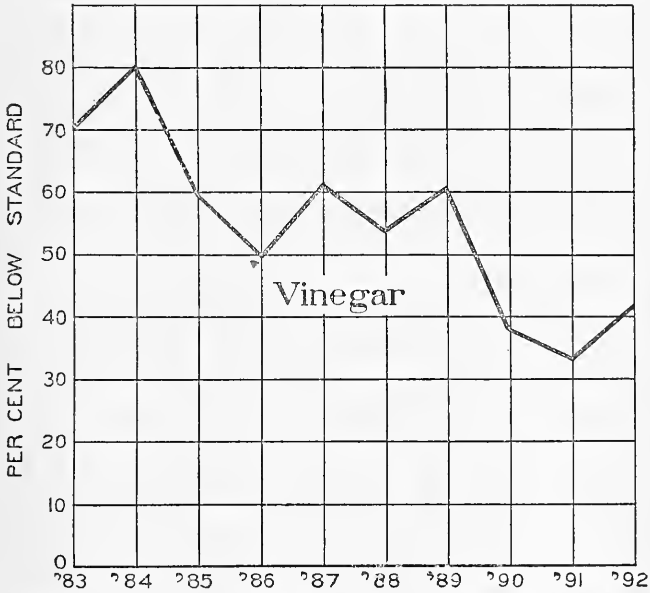
Cocoa and Chocolate.

No adulteration has been found.

Cider Vinegar.

The adulteration consists in the deficiency in acetic acid and in the normal apple solids of cider vinegar. Ratio of adulteration, 41 per cent.

CHART V. — *Showing the Percentage of Adulterated Samples of Vinegar examined during the Ten Years ending Sept. 30, 1892.*



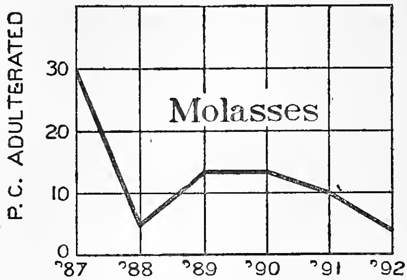
Years.	Per Cent. of Adulteration.	Years.	Per Cent. of Adulteration.
1883, ...	70.6	1888, ...	53.8
1884, ...	80.7	1889, ...	60.9
1885, ...	59.6	1890, ...	38.2
1886, ...	50.1	1891, ...	33.3
1887, ...	61.4	1892, ...	41.7

Molasses.

The mixture of glucose with molasses is becoming rare. The detection of glucose is determined by polarization before and after inversion.

Adulterant, glucose. Ratio of adulteration, 3 per cent.

CHART VI. — *Showing the Percentage of Adulterated Samples of Molasses examined during the Five Years ending Sept. 30, 1892.*



YEARS.	Per Cent. of Adulteration.	YEARS.	Per Cent. of Adulteration.
1887, ...	29.4	1890, ...	13.3
1888, ...	4.7	1891, ...	10.0
1889, ...	13.3	1892, ...	3.6

Syrups.

Samples of lemon and lime syrups were found preserved with salicylic acid.

Maple Sugar.

The usual adulteration practised is the adulteration, amounting often to total substitution, of the cheapest grades of brown cane sugar. These can usually be distinguished from genuine maple sugar by the large amount of invert sugar which they contain ; but, after all, chemical testimony is hardly necessary to condemn much of the January and February " new maple sugar " that annually comes from molasses barrels.

The addition of glucose to maple sugar has not been found.

Maple Syrup.

The chief adulterant is glucose syrup, which is readily determined by the polariscope. Ratio of adulteration, 16 per cent.

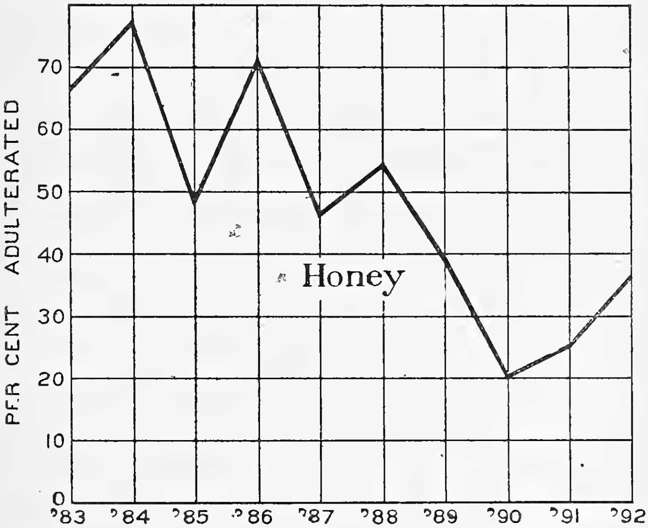
Confectionery.

There is no reason why any edible substance should be considered an adulterant of cheap candy. Most of it consists of starch, glucose and sugar. No gypsum has been found. The coloring matter in two instances has been found to be the poisonous chromate of lead. All the other colors were found to be harmless.

Honey.

The consistency of honey is so nearly that of glucose syrup that it is not remarkable that it should be adulterated with this cheapener. The presence of dextrine may be determined by treatment with alcohol. The amount of glucose, if any present, is estimated from the polariscope readings before and after inversion. Ratio of adulteration, 36 per cent.

CHART VII. — *Showing the Percentage of Adulterated Samples of Honey examined during the Ten Years ending Sept. 30, 1892.*

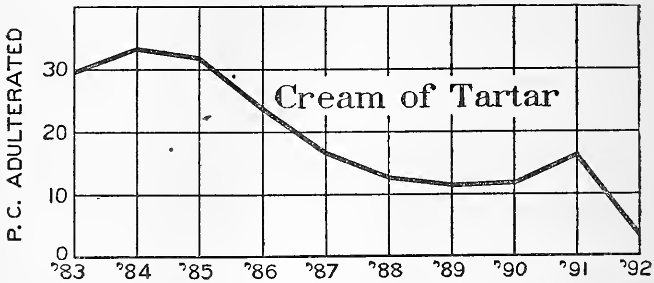


YEARS.	Per Cent. of Adulteration.	YEARS.	Per Cent. of Adulteration.
1883, ...	66.7	1888, ...	54.5
1884, ...	77.4	1889, ...	39.5
1885, ...	48.7	1890, ...	20.6
1886, ...	71.3	1891, ...	25.5
1887, ...	46.7	1892, ...	36.5

Olive Oil.

Adulterants, seed oil, usually cotton seed. The nitric acid test has never given doubtful results. Ratio of adulteration, 33 per cent.

CHART VIII. — *Showing the Percentage of Adulterated Samples of Cream of Tartar examined during the Ten Years ending Sept. 30, 1892.*



YEARS.	Per Cent. of Adulteration.	YEARS.	Per Cent. of Adulteration.
1883, ...	29.8	1888, ...	12.7
1884, ...	33.2	1889, ...	11.4
1885, ...	31.8	1890, ...	11.9
1886, ...	23.8	1891, ...	16.3
1887, ...	16.9	1892, ...	3.5

Cream of Tartar.

It will be seen by reference to Chart VIII. that there is a very marked improvement in the quality of cream of tartar. An adulterated sample is now a rarity. All the adulterated samples have contained constituents insoluble in hot water. This affords a ready household test.

Adulterants found were starch, gypsum and acid phosphate of lime. Ratio of adulteration, 3 per cent.

Baking Powders.

The few samples of baking powders which the inspectors have brought in have been only such new brands as they have found in the market. It has been found among those examined that such brands as offer prizes of any sort to purchasers prove to be of poor quality. Usually such prize powders contain alum as an important constituent.

Canned Goods.

French Pease. — A quantitative estimation of the copper used in greening the various brands of French pease in the market was made. The amount of copper found varied from none (Phillipe & Canaud) to 2.75 grains per can (Cadeau & Cie), calculated as the sulphate.

In the prosecutions brought by the Board for the sale of coppered pease the complaint was made that the pease were "colored by the addition of a poisonous ingredient, viz., a salt of copper," and that "they were colored so as to appear better, or of greater value, than they really were." The defence argued that the salt of copper was added, not to give an artificial green color, but in order to preserve the original green of the chlorophyl, so that it shall not be destroyed by boiling. A clear demonstration of the fallacy of this argument was prepared in rebuttal, but legal objections prevented its being allowed in evidence. If the copper acts as a preservative of the chlorophyl, a pure extract of chlorophyl should be prevented from destruction by boiling by the addition of sulphate of copper. But a simple experiment shows that it is not so preserved. And, again, after the chlorophyl of the pea is once destroyed by boiling, it should not be possible to restore it by further boiling with copper sulphate.

But it is easy to give boiled pease which are of a yellowish color the exact shade of green found in the canned vegetables, by reboiling with just the quantity of copper sulphate which is used by the French canners. Copper salts when boiled with albumens form green compounds of various shades, according to the amount of copper present and the variety of albumen used.

The copper albuminate or leguminate made by boiling pease devoid of chlorophyl in dilute copper solution appears to be identical with the substance of the colored French pea.

Canned Corn. — Much of the canned corn in the market is of an unnaturally white color. Such corn has been bleached by artificial means before canning, usually by boiling with the sulphite of soda. Several of these bleached brands have been examined, to determine whether anything injurious (especially compounds of sulphur) could be found in the finished product.

The sulphite originally added must be present either in the original form of sulphite, or reduced to a sulphide, oxidized to a sulphate, or oxidizable if in organic combination.

Equal quantities of the bleached corn and canned corn of known purity were acidified with phosphoric acid and distilled in a current of carbonic acid gas. The amounts of sulphuretted hydrogen in both cases were practically equal. The merest trace of sulphurous acid was present in both distillates. The total sulphur was estimated by burning the dried and powdered corn with an excess of nitrate of

potash, and precipitating the sulphate with barium chloride. The sulphate from the bleached corn was slightly in advance of the unbleached, but the difference was insignificant.

The average of several estimations gave sulphuric acid in normal corn per 100 grammes, 0.21 grammes; sulphuric acid in bleached corn per 100 grammes, 0.24 grammes.

Condensed Milk. — The following brands were examined for water, fats and other solids. The contents of two cans were examined for lead and tin, and a trace of lead was found in one: —

	Brand.	Per Cent. Water.	Total Solids.	Solids not Fat.	Per Cent. Fat.
Condensed milk, ...	Newport, ...	22.21	77.79	71.95	5.84
Condensed milk, ...	Star, ...	22.33	77.67	73.08	4.59
Condensed milk, ...	Red Cross, ...	24.48	75.52	68.14	7.38
Condensed milk, ...	Superior, ...	25.87	74.13	68.68	5.45
Condensed milk, ...	Atlantic and Pacific Tea Company, . . .	26.90	73.10	67.25	5.85
Condensed milk, ...	Red Cross, ...	28.34	71.66	63.95	7.71
Evaporated cream, . . .	Highland, ...	58.56	41.44	29.00	12.44
Evaporated cream, . . .	Highland, ...	66.74	33.26	26.14	7.12
Evaporated cream, . . .	St. Charles, . . .	68.77	31.23	27.40	3.83
Evaporated cream, . . .	St. Charles, . . .	70.36	29.64	23.87	5.77

Lard.

Of 41 samples, 9 were either mixtures or total substitutions of tallow and seed oil.

Miscellaneous.

Of this class, 59 samples were of good quality, and 21 not as represented, or injurious. Under this head were examined samples of: —

Pickles, none of which contained copper; a few contained alum.

Spaghetti, all of good quality.

Gelatine, of good quality.

Horse-radish, of good quality.

Jelly, nearly all made of a cheap apple jelly, more or less disguised to represent currant, grape, etc.

Dried Apples. — The evaporated apples are often bleached with sulphur and dried on galvanized-iron wire. Several samples were found to contain large traces of zinc from this contact.

Salt Fish. — A sample was found preserved with boracic acid in addition to the salt. This can scarcely be accounted injurious, since salt fish is well soaked out before being eaten.

Catsup, etc. — Several samples of tomato catsup were found to be preserved with salicylic acid.

Samples of the Burnham brand of clam juice, which was advertised as just the thing for weak and delicate stomachs, were found to contain 0.19 gram of salicylic acid per fluid ounce.

N'egg. — Two little boxes, one of a white, dry powder, the other of a yellow powder, are advertised to contain the nutritive equivalent of the whites and yolks of one dozen of fresh eggs. This preparation "is based on careful scientific analysis of natural eggs." The white and yellow powders "differ in composition, as do the whites and yolks of eggs." But "careful scientific analysis of natural eggs" without exception attributes a certain amount of albumen at least to the whites of eggs. Now the albumen has been omitted from the composition of "n'egg," and not a single authority can be found who has discovered that eggs are composed of nearly pure tapioca starch; but this is the composition of "n'egg:" tapioca starch and a little salt is the white, and the same colored with an organic dye is the yellow. Their microscopical appearance is represented in Fig. 20.

The following table gives a summary of the food statistics during the year: —

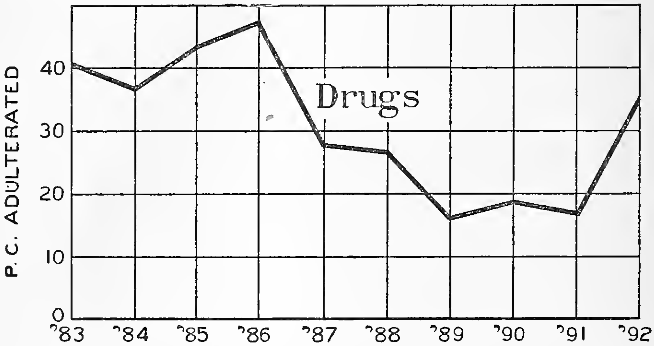
Summary of Food Statistics.

	Genuine.	Adulterated.	Total.		Genuine.	Adulterated.	Total.
Allspice,	90	3	93	Mace,	22	0	22
Baking powder,	2	3	5	Maple sugar,	17	0	17
Butter,	287	61	348	Maple syrup,	35	7	42
Canned goods,	29	49	78	Miscellaneous,	59	21	80
Cassia,	108	10	118	Molasses,	113	4	117
Cayenne,	5	2	7	Mustard,	89	44	133
Cheese,	39	0	39	Nutmeg,	2	1	3
Chocolate,	2	0	2	Olive oil,	18	9	27
Cloves,	164	17	181	Pepper,	228	45	273
Coffee,	60	32	92	Spaghetti,	3	0	3
Confectionery,	42	2	44	Syrups,	6	7	13
Cream of tartar,	315	11	326	Tea,	88	5	93
Ginger,	85	4	89	Vinegar,	52	37	89
Honey,	42	24	66				
Lard,	32	9	41		2,034	407	2,441

Drugs.

Of this class, 487 articles have been examined during the year, of which 175 proved to be not of the quality demanded by the Pharmacopœia.

Chart IX. — *Showing the Percentage of Adulterated Samples of Drugs examined during the Ten Years ending Sept. 30, 1892.*



Years.	Per Cent. of Adulteration.	Years.	Per Cent. of Adulteration.
1883, ...	40.7	1888, ...	26.5
1884, ...	36.8	1889, ...	16.1
1885, ...	43.3	1890, ...	18.7
1886, ...	47.4	1891, ...	16.9
1887, ...	27.7	1892, ...	35.5

Acidum Benzoicum: 10 standard; 2 inferior, containing notable amounts of chlorobenzoic and cinnamic acids.

Acidum Hydrobromicum: 5 standard; 1 inferior in strength.

Acidum Tannicum: 18 standard; 1 inferior, adulterated with dextrine and wheat starch.

Æther: 7 standard; 3 inferior, containing too much alcohol and water.

Æther fortior: 4 standard; 7 inferior, containing too much alcohol and water.

Alcohol: 16 standard; 6 inferior, containing too much water.

Aloes: 3 standard.

Aqua Ammoniæ: 13 standard; 1 inferior, containing too much water.

Aqua Chlorinæ: 1 inferior, containing no chlorine whatever.

Aqua Distillata: 2 standard; 8 inferior, tap water or condensed steam fouled with oil.

Argenti Nitras: 16 standard.

Bismuthi Subcarbonas: 11 standard.

Bismuthi Subnitras: 20 standard; 4 inferior, containing much carbonate.

Cerii Oxalas: 7 standard.

Chloral Hydras: 3 standard.

Chloroform: 3 standard; 1 inferior, containing too much alcohol.

Extractum Glycyrrhizæ: 2 standard; 8 inferior, containing notable quantities of corn starch.

Ferri et Quininæ Citras: 14 not standard (including one *Liquor Ferri et Quininæ Citras*), all containing notable quantities of ammonia.

Glycerinum: 13 standard; 3 inferior, containing too much water and fatty impurities, which reduce nitrate of silver.

Glycyrrhizinum Ammoniatum: 3 standard.

Iodoform: 11 standard; 1 inferior, containing a considerable amount of calcium sulphate.

Lycopodium: 9 standard.

Liquor Magnesii Carbonatis: 1 standard; 1 inferior, containing not more than half the required solids.

Liquor Magnesii Citratis: 5 standard; 3 inferior, deficient in solids.

Magnesii Citras: 2 standard.

Oleum Æthereum: 1 standard; 1 inferior, containing sulphuric acid.

Oleum Olivæ: 3 standard; 2 seed oils; about the same proportion of purity as among the olive oils of the grocers.

Opii Pulvis: 8 standard; 5 inferior, containing less than the standard morphine. The morphine strength of these powders was but slightly below the standard, in marked contrast to the tinctures of opium.

Pulvis Effervescens Compositus: 4 standard in quality, but of considerable variety in weight.

Pulvis Rhei: 10 standard.

Quininæ Bisulphas: 1 standard.

Quininæ Sulphas: 9 standard.

Spiritus Ætheris Compositus: 1 standard; 2 inferior, containing too much water and too little ethereal oil.

Spiritus Ætheris Nitrosi: 3 standard; 3 inferior, deficient in ethyl nitrite.

Spiritus Juniperi: 3 inferior. These proved to be variable mixtures of water with alcohol and a juniper flavoring.

Syrupus: 6 standard; 3 inferior, being old, partially decomposed and full of spores.

Tinctura Aconiti: 6 standard; 1 inferior, deficient in solid extract.

Tinctura Iodi: 4 standard; 14 inferior, being deficient in iodine.

Tinctura Nucis Vomicæ: 2 standard; 5 inferior, deficient in solid extract. The standard tincture contains 2 per cent. of solid extract; the tinctures examined varied from 5.7 to 0.8 per cent. of extract. The actual amount of strychnine prescribed in *tinctura nucis vomicæ* thus seems to be a decidedly uncertain quantity.

Tinctura Opii (including *Tinctura Opii Deodorata*): 12 standard; 17 inferior. The Pharmacopœia directs that the tincture of opium shall contain from 1.2 to 1.6 per cent. of morphine. The amount of morphine contained in these tinctures varied from 0.37 to 2.6 per cent., and several were sold without the poison label prescribed by law. The importance of conforming to a standard in drugs of such power as tinctures of nux vomica and opium is too evident to need more than mention.

Liquors.

Gin: 3 samples of fair purity.

Spiritus Frumenti: 2 standard; 3 inferior. The alcoholic strength of these samples was not far from the standard, but the solid residue was greatly increased, sugar being the chief addition.

Spiritus Vini Gallici: 6 samples not conforming to standard. In alcohol these samples were of standard quality, but the solid residue was from four to eight times the pharmacopœial requirement. The addition was chiefly sugar.

Vinum Album: 9 not of standard quality. The chief deviation from the standard here was in the increased sugar, which made the solids from 4 to 13 per cent., the maximum allowable being 3 per cent.

Vinum Rubrum: 3 of standard quality; 13 inferior. The amount of solid matter (chiefly again added sugar) was from 4 to 20 per cent. The maximum allowable is 3.5 per cent.

Face Washes.

Of face lotions, 13 samples have been examined, chiefly with reference to determining the presence or absence of poison; 10 of them were found to contain corrosive sublimate in solution. A six-ounce bottle yielded as much as 47 grains of the mercuric chloride. The

brands that were found to contain poison were: Hill's Freckle Lotion, Searle's Freckle and Moth Eradicator, Perry's Freckle Lotion, Mme. Ruppert's Face Bleach, Oriental Cream. Most of these were nearly pure solutions of corrosive sublimate. An attempt to evade the poison law was found in the case of Mme. Ruppert's lotion, which bore the red poison label on the bottom of the bottle, out of sight.

The non-poisonous washes were found to be various mixtures of soap, borax, citric acid and calomel, alcohol and water.

It is extraordinary that small bottles of mixtures of this sort find such a ready sale at a price of one or two dollars. The actual cost of the preparation can rarely exceed ten cents a bottle.

Miscellaneous.

Of 16 samples under this head, 8 were good quality, 8 of poor quality or poisonous. In this class were included samples of confectioners' colors, none of which could be considered injurious to health.

Samples of a German fly paper were found to contain 7.8 grammes of arsenite of potash (about a third of an ounce) per sheet. For use small pieces of this paper are soaked in a saucer of sweetened water and left by a window for the flies. There is no warning to the purchaser of the poisonous nature of the paper, and fatal results have followed its use in households where children have been attracted by the sweetened water.

Compound Extract of Sarsaparilla.

Although the compound fluid extract of sarsaparilla is an officinal preparation, it has become, at least in name, one of the favorite preparations of the patent medicine shops. The usual bottle of so-called "sarsaparilla" costs a dollar, and holds nearly a pint of extract of a variety of herbs and roots, with a considerable amount of molasses, a little alcohol and the iodide of potash.

In many cases a more extended label reads "The compound extract of sarsaparilla with the iodide of potash," while in others the careful explanation is made that "this extract contains no iodide of potash." But it has been found that these assurances are not always reliable, for some that profess to contain "the valuable medicinal agent" (iodide of potash) contain it not, while others that call particular attention to the absence of that "noxious drug" contain

notable quantities, if not of the iodide of potash, at least of some other soluble iodide which is to all intents and purposes the same.

The 40 samples of these extracts examined were found to contain a soluble iodide which has been calculated as the iodide of potash. In some instances part of the iodine at least was in the form of iodide of iron, and in others probably the sodium salt.

The large and variable amounts of potassium contained in the various constituents, render it impossible to make any estimate of the *added* potassium.

The iodine was determined by the volumetric method applicable to solutions containing other haloids.

The results calculated as the iodide of potassium are as follows:—

Name of Brand.	Per Cent. of Potassium Iodide.	Amount of Potassium Iodide in Grammes per Bottle.	Name of Brand.	Per Cent. of Potassium Iodide.	Amount of Potassium Iodide in Grammes per Bottle.
Allen's,	0	0	Hutchinson's,	0.75	2.63
Atlantic,	0	0	Dr. White's,	0.75	2.63
Corbett's (Shakers),*	0	0	Coleman & Co.'s,	0.83	2.92
Holbrook's,	0	0	Bass's,	0.84	2.94
Putnam's,	0	0	Brown's,	1.00	3.50
No Name,	Trace.	Trace.	Leavitt's,	1.00	3.50
Willson's,	0.32	1.12	Moriarty's,	1.11	3.88
Howe's,	0.33	1.15	Dana's,	1.17	4.09
White's,	0.38	1.33	Woodward's,	1.33	4.65
No Name,	0.41	1.46	Dudley's,	1.50	5.26
Charles',	0.41	1.46	Dudley's, from another dealer,	1.50	5.26
Mahern's,	0.41	1.46	Cherry & Wingate's,	1.55	5.42
Ayer's,	0.45	1.61	Jaynes',†	1.59	5.56
Bartlett's,	0.50	1.75	Nim's,	1.67	3.34‡
No Name,	0.50	1.75	Cherry & Wingate's,	1.67	5.85
No Name,	0.50	1.75	Mattison's,	2.00	7.00
Packard's,	0.58	2.04	Myrick's,	2.12	7.42
Raynsford's,	0.58	2.04	Leavitt's,	2.17	7.59
Adams',	0.75	2.63	Church's,	2.25	7.87
Broad & Co.'s,	0.75	2.63			
Hood's,	0.75	2.63			

* Label states "Contains one ounce of hydriodate of potassium per twelve bottles."

† "Contains no iodide of potash," according to label.

‡ Small bottle.

SUMMARY.

	Genuine.	Adulterated.	Total.
Foods not milk,	2,034	407	2,441
Milks,	1,555	1,464	3,019
Drugs,	312	175	487
TOTALS,	3,909	2,038	5,947

Respectfully submitted,

CHARLES P. WORCESTER,
Analyst.

EXPLANATION OF PLATES.

The following photographs show the microscopic appearance of typically adulterated spices. Such photographs have proved of value in court in convincing a jury of the adulteration of certain samples.

The apparatus used in taking these pictures is the simplest possible. An upright board, firmly supported on a horizontal base, carries a frame for a photographic plate holder. A rubber gauze skirt hangs from this frame, and is gathered and tied about the eye-piece of the microscope. The specimen is mounted in a warm solution of gelatine, which soon sets and firmly encloses the small particles, whose vibratory motion is thus stopped.

PLATE I.

MICROSCOPIC APPEARANCE OF COFFEE—GENUINE AND ADULTERATED.

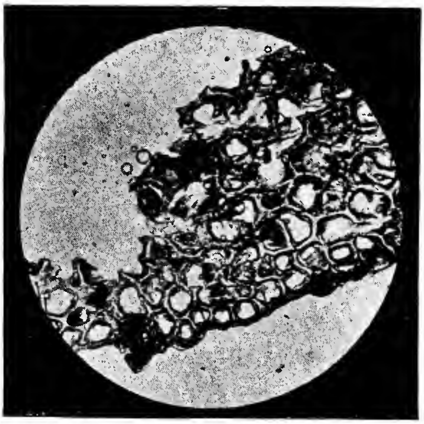


FIG. 1.

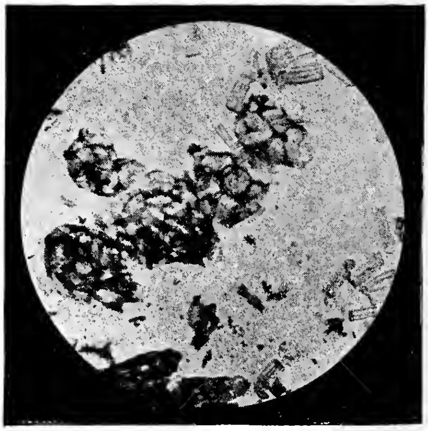


FIG. 2.

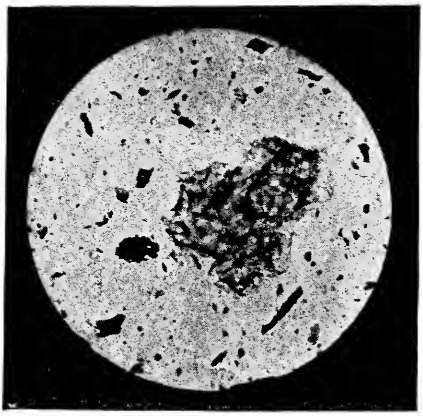


FIG. 3.

FIG. 4.

Fig. 1. ***Coffee (genuine).***
A loose mesh of irregularly hexagonal cells, thick walled, and enclosing oil drops with amorphous material.

Fig. 2. ***Coffee adulterated with roasted peas.***
No genuine coffee appears in this field. The chief masses are characteristic aggregations of the round starch cells of the pea. The rectangular billets, like bunches of matches, are the cells composing the skin of the pea.

Fig. 3. ***Coffee adulterated with roasted wheat and charcoal.***
No genuine coffee appears in this field. The central mass is of wheat starch cells much distorted by roasting. The black, angular lumps are of common wood charcoal.

Fig. 4. ***Coffee adulterated with chiccory.***
Chiccory alone appears in this field. It is a mass of confused cellular tissue traversed by two broad bands with striking transverse markings. These bands are the juice ducts.

PLATE II.

MUSTARD AND PEPPER.

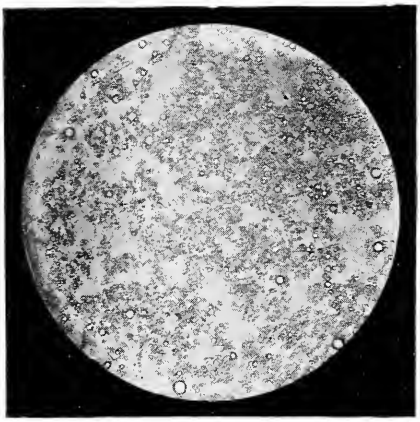


FIG. 5.

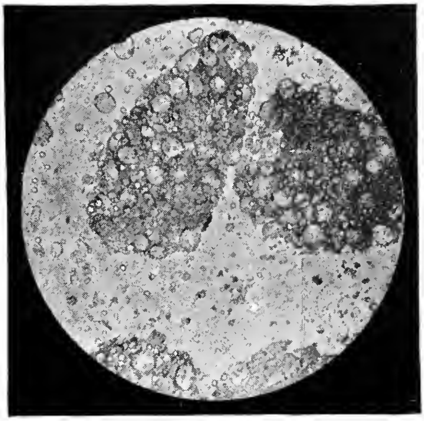


FIG. 6.

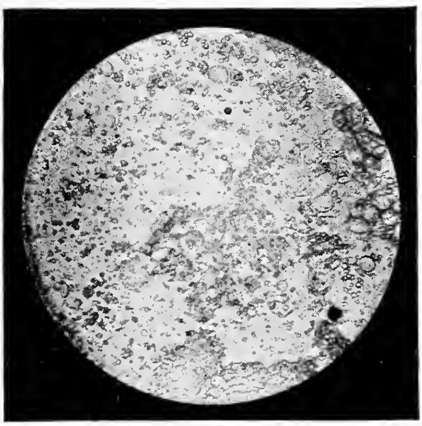


FIG. 7.

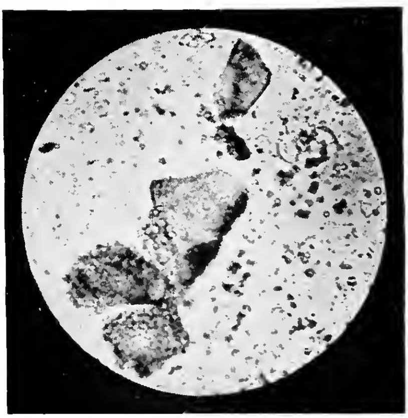


FIG. 8.

Fig. 5. ***Mustard (genuine).***
Fine granular masses, with drops of oil.

Fig. 6. ***Mustard adulterated with wheat.***
But little appears besides the masses of large and small wheat starch grains.

Fig. 7. ***Mustard adulterated with wheat and rice.***

Fig. 8. ***Pepper adulterated with buckwheat.***
A mass of genuine pepper starch appears at the top. The masses below are the coarser grained buckwheat starch.

PLATE III.

PEPPER.

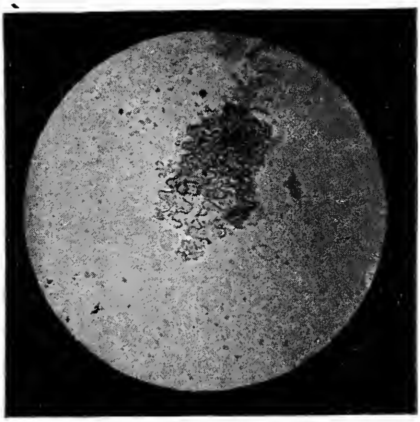


Fig. 9.

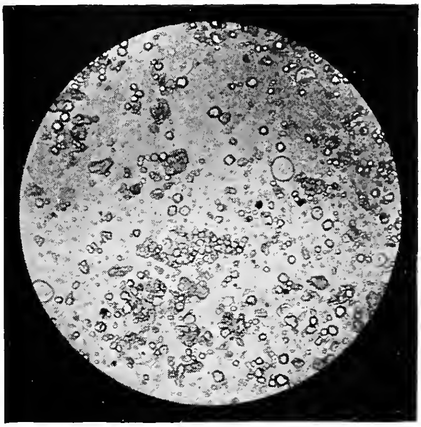


Fig. 10.

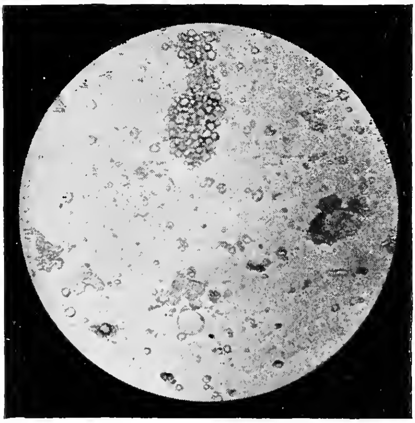


Fig. 11.

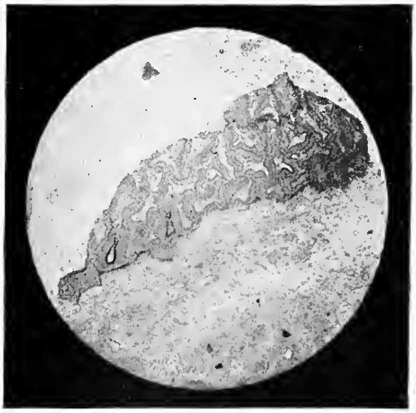


Fig. 12.

Fig. 9. ***Pepper.***
Consisting of wheat and cayenne.

Fig. 10. ***Pepper.***
Adulterated with wheat (the large round grains), corn (the next smaller angular grains), and buckwheat (the smallest angular grains).

Fig. 11. ***Pepper adulterated with wheat.***

Fig. 12. ***Cayenne (genuine).***

PLATE IV.

CAYENNE PEPPER AND GINGER.

Fig. 13.

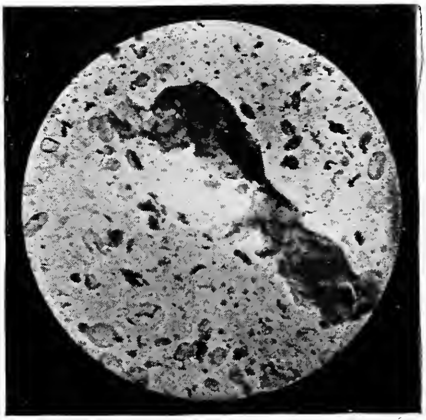


Fig. 14

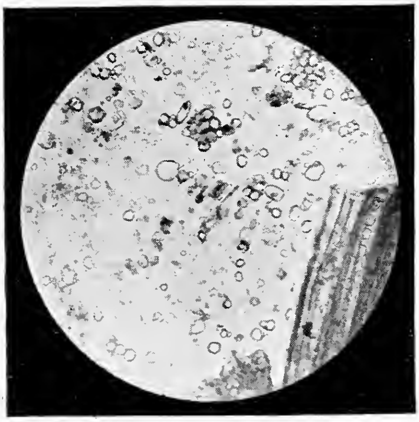


Fig. 15.

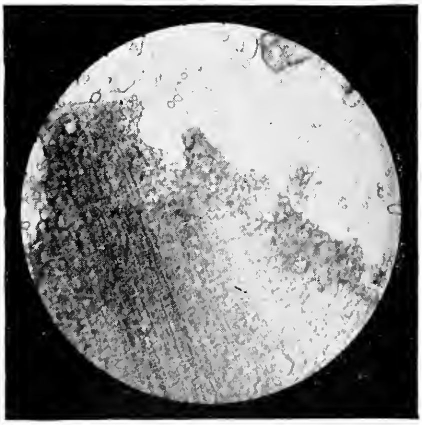


Fig. 16.

Fig. 13. ***Cayenne adulterated with ground cocoa-nut shells, wheat and corn.***

Fig. 14. ***Ginger adulterated with ground turmeric.***
The large mass in the centre is of turmeric, the strongly ribbed starch grains being faintly shown.

Fig. 15. ***Compound ginger.***
Consisting chiefly of wheat, corn and sawdust. The mass in the lower right-hand corner shows the characteristic structure of a soft wood. (See page 633.)

Fig. 16. ***Ginger adulterated with wheat bran.***

PLATE V.

CLOVES, AND EGG SUBSTITUTE.

FIG. 17.

FIG. 18.

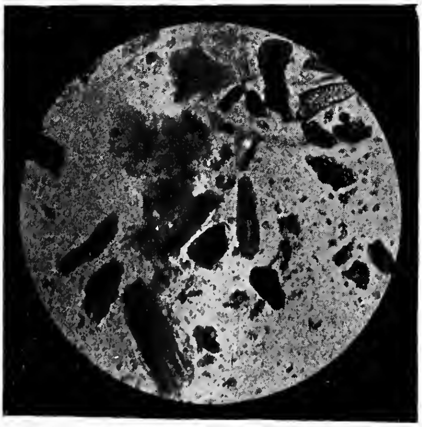


FIG. 19.

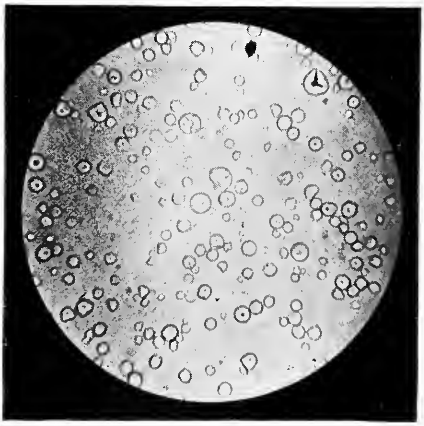


FIG. 20.

Fig. 17. ***Cloves (genuine).***
A loose cellular mesh containing numerous small highly refractory oil drops.

Fig. 18. ***Cloves adulterated with ground cocoa-nut shells.***
But little else appears besides the hard "stone cells" of the adulterant.

Fig. 19. ***Cloves adulterated with nut shells.***

Fig. 20. ***N'egg.***
Tapioca starch.

PROFESSOR GOESSMANN'S REPORT.

Milk of Western Massachusetts.

The following summary presents the results of the examination of the milk obtained by the inspectors in cities and towns of the four western counties of Massachusetts during the year ending Sept. 30, 1892.

The whole number examined was 252, of which 202 were above, and 50, or 19.8 per cent., below, the standard.

Five samples of skimmed milk, sold as such, were collected, and are included in this summary.

	Total.	Above Standard.	Below Standard.	Per Cent. below Standard.	Skimmed.
Amherst,	1	1	0	0	-
Chicopee,	16	14	2	12.50	2
Great Barrington,	12	8	4	33.34	-
Greenfield,	1	0	1	100.00	-
Holyoke,	64	55	9	14.06	-
Lenox,	7	5	2	28.57	1
North Adams,	29	23	6	20.69	1
Northampton,	11	9	2	18.18	1
Springfield,	79	65	14	17.72	-
Ware,	16	11	5	31.25	-
Westfield,	16	11	5	31.25	-
Totals,	252	202	50	19.84	5

C. A. GOESSMANN,
Analyst.

Amherst, Mass., September 20.

MORTALITY REPORTS.

THE WEEKLY MORTALITY REPORTS OF MASSACHUSETTS CITIES AND TOWNS.

At the end of each week it has been the custom of the officials in many of the cities and large towns of Massachusetts having charge of the collection of the vital statistics to send a postal-card report of the deaths which have occurred during the week. These reports are compiled at the office of the Board and published each week as a bulletin, one copy of which is sent to each city and town in the State.

These returns are voluntary, and hence are incomplete, since they comprise the statistics of mortality of a part of the population only. It is to be hoped that the legislation of the present year (1893) relating to the reports of contagious diseases to the State Board of Health will stimulate the authorities of cities and towns to make these postal-card reports more full and complete.

The estimated population of the cities and towns contributing to this report for the year 1892 was about 1,400,000, or about 60 per cent. of the population of the State.

The data embraced in this summary are the following: —

Average height of barometer for each week.
Mean or daily maximum temperature.
Mean or daily minimum temperature.
Rainfall expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet-fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.

In the report of the last year (1891) a summary of the statistics of nine years was presented, with diagrams illustrating the weekly mortality from each disease for the whole period, as well as for the year 1892.

General Summary.

Day of Month.		Barometer.	Maximum Thermometer for each Week.	Minimum Thermometer for each Week.	Rain — Inches.*	Humidity.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet-fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Malarial Fever.	Small-pox.	Puerperal Fever.	Erysipelas.	Death Rate per 1,000.
Jan.	2,	30.10	42	28	-	62	852	197	72	245	4	31	11	1	4	2	-	-	1	-	36.75
	9,	29.79	36	24	-	70	862	196	85	260	5	24	10	1	6	3	-	-	1	2	36.56
	16,	30.34	36	24	-	87	828	185	74	263	8	20	8	-	8	3	-	-	-	3	34.39
	23,	30.16	36	18	-	76	679	157	71	174	10	20	9	-	5	6	-	-	-	1	28.75
	30,	29.78	32	16	4.81	66	613	161	74	130	5	23	10	-	3	6	-	-	1	1	26.17
Feb.	6,	29.99	35	22	-	72	510	162	58	97	6	16	11	-	3	5	-	-	2	3	20.49
	13,	29.69	32	21	-	80	527	146	46	111	9	19	6	-	4	3	-	-	2	1	21.62
	20,	30.26	34	19	-	65	574	181	60	107	2	11	12	1	3	4	-	-	1	-	23.31
	27,	30.47	36	31	2.09	90	517	144	54	103	3	13	6	-	1	4	-	-	-	-	20.52
March	5,	30.08	32	29	-	80	512	173	62	94	7	19	12	1	9	4	-	-	2	1	21.74
	12,	29.65	44	30	-	68	528	160	60	81	7	20	12	1	5	4	-	-	1	3	21.23
	19,	29.99	33	19	-	60	555	160	56	98	7	20	6	-	4	2	-	-	-	6	22.67
	26,	30.08	43	28	3.20	58	540	175	67	81	6	22	5	1	8	1	-	-	2	2	22.25
April	2,	30.13	50	34	-	52	602	188	67	89	3	16	12	-	5	1	-	-	2	-	23.90
	9,	29.83	66	45	-	61	562	177	72	97	5	22	11	-	5	2	-	-	-	3	23.95
	16,	29.84	49	33	-	46	563	169	70	100	5	21	11	2	6	1	-	-	2	3	22.68
	23,	30.07	58	40	-	59	547	168	71	95	7	22	13	1	6	-	-	-	2	3	22.17
	30,	30.24	55	38	1.02	49	530	147	64	74	2	16	11	-	5	7	-	-	2	-	21.47
May	7,	30.03	62	45	-	62	520	149	81	85	6	17	9	-	7	1	-	-	-	1	23.04
	14,	30.06	58	46	-	68	504	151	62	70	4	23	13	-	12	2	-	-	3	1	20.09
	21,	29.96	59	48	-	72	518	137	60	87	8	18	11	4	8	1	2	-	1	-	19.56
	28,	29.72	67	51	5.23	69	542	146	68	75	4	28	14	-	9	4	1	-	-	3	21.39
June	4,	30.12	76	60	-	71	500	146	63	47	7	15	7	1	4	1	-	-	2	4	28.84
	11,	30.05	73	56	-	66	416	131	54	48	6	11	9	3	15	4	1	1	1	4	17.23
	18,	30.01	83	63	-	67	498	159	62	43	3	19	8	4	24	2	-	1	1	1	20.06
	25,	29.79	77	64	3.92	73	412	126	49	28	4	8	7	-	20	1	1	-	-	1	16.96
July	2,	29.97	74	60	-	78	378	134	48	40	1	7	6	-	24	1	-	-	1	1	15.39
	9,	30.18	74	60	-	62	475	191	62	24	6	13	3	1	74	3	-	-	-	3	17.90
	16,	29.92	86	68	-	67	640	315	78	28	8	12	2	1	151	4	-	-	-	3	23.50
	23,	30.02	82	62	-	56	678	389	56	18	4	11	2	1	257	2	1	-	3	-	24.68
	30,	29.93	87	70	2.91	64	926	534	53	22	9	9	8	1	355	2	-	-	-	-	34.94
Aug.	6,	29.99	73	63	-	82	729	410	56	28	5	6	5	1	271	1	-	-	-	-	27.25
	13,	29.98	83	68	-	76	706	372	66	26	10	8	6	1	213	2	2	-	-	1	27.45
	20,	30.04	81	65	-	70	661	327	61	13	10	14	5	-	185	1	-	-	-	-	24.21
	27,	30.05	71	61	5.45	77	498	252	47	14	12	3	2	-	132	5	-	-	2	-	19.56

Sept. 3,	30.12	69	56	-	77	536	238	56	16	6	8	3	-	106	4	-	-	1	-	21.78
10,	30.23	69	54	-	76	496	214	41	28	12	8	2	-	93	1	-	-	2	-	18.91
17,	30.13	71	54	-	79	541	226	60	42	7	15	1	-	71	6	1	-	-	-	20.56
24,	30.12	74	58	2.24	76	457	176	49	40	21	11	4	-	51	1	-	-	-	1	18.03
Oct. 1,	29.99	69	52	-	61	415	133	55	28	20	16	2	-	33	-	-	-	-	-	17.41
8,	29.80	61	46	-	68	467	152	57	35	18	10	5	-	21	1	-	-	2	-	18.25
15,	30.12	64	48	-	68	438	125	46	41	17	13	7	1	16	-	1	-	-	2	17.73
22,	30.00	61	49	-	71	412	126	57	35	14	19	13	-	16	2	-	-	1	-	16.69
29,	29.79	55	41	1.50	66	453	131	69	46	14	24	9	3	16	1	-	-	1	1	18.90
Nov. 5,	29.98	50	40	-	74	428	98	53	60	10	18	10	-	11	1	-	-	-	1	15.65
12,	30.11	49	34	-	68	512	157	67	66	19	27	15	-	13	1	-	-	1	2	18.84
19,	30.05	56	43		83	485	150	59	57	6	26	12	-	10	1	1	-	2	1	16.86
26,	29.99	41	27	5.10	62	420	109	53	62	11	23	7	-	4	1	1	-	-	1	16.84
Dec. 3,	29.96	39	31	-	79	472	144	64	70	10	29	12	2	4	1	1	-	1	-	17.62
10,	29.95	43	31	-	75	455	141	59	59	10	22	14	-	5	2	-	-	1	5	16.83
17,	30.18	41	30	-	73	455	132	57	71	8	19	15	3	3	1	-	-	1	1	17.40
24,	29.90	30	17	-	64	497	141	55	89	15	24	10	1	2	1	-	-	2	2	19.07
31,	30.03	30	14	1.32	58	645	178	72	111	15	39	12	1	6	1	-	-	1	2	23.23
Total,	-	-	-	38.79	-	29,086	9,884	3,238	3,951	441	928	446	38	2,332	121	13	2	51	74	20.76
Weekly average,	-	-	-	.74	-	548	186	62	74	8	18	8	1	40	2	-	-	1	1	-
Rate per 1,000 deaths,	-	-	-	-	-	-	339.82	111.33	135.7	15.15	31.9	15.33	1.31	80.	4.16	.45	-	1.75	2.54	-
Rate per 1,000 of the estimated population,	-	-	-	-	-	21.10	7.17	2.31	2.82	.31	.66	.32	.03	1.66	.08	-	-	.04	.05	-

Average reporting population, ... 1,378,471

* Monthly averages for New England.

Total Deaths.

The whole number of deaths reported for the year 1892, from the cities and towns contributing to these reports, was 29,086, and the average number per week was 548. The greatest number of deaths reported in a single week was 926, in the week ending July 30, and the least number was 378, in the week ending July 2.

The weekly average number of deaths reported for each month was as follows: —

January,	767	July,	619
February,	532	August,	648
March,	534	September,	508
April,	561	October,	437
May,	421	November,	461
June,	456	December,	505

The months in which the greatest mortality was reported were January, July and August, and those in which there was the least reported mortality were May, June and October.

The percentages of mortality in each of the four quarters of the year were as follows: —

	All Ages.		Ages under 5 Years.	
	Numbers.	Percentages.	Numbers.	Percentages.
First quarter,	8,097	27.84	2,197	22.23
Second quarter,	6,714	23.08	1,994	20.17
Third quarter,	7,721	26.55	3,776	38.20
Fourth quarter,	6,554	22.53	1,917	19.40
	29,086	100.00	9,884	100.00

In the foregoing table it appears that the greatest mortality at all ages was in the first quarter, and the least in the last quarter; the influenza epidemic having again asserted itself in the winter of 1891–92, to a still greater degree than was manifest in the winter of 1889–90.

The comparative mortality of children under five in the different

quarters of the year did not differ materially from that of previous years, the greatest mortality being in the third quarter.

Deaths under Five Years.

The reported number of deaths of children under five years of age was 9,884, and the average weekly number was 186. The greatest number reported in one week was 534, in the week ending July 30, and the least number was 98, in the week ending November 5. The ratio of the deaths of this class to the total reported mortality was 34.1 per cent., which was slightly less than that of the preceding year (35.5 per cent.).

The average weekly number of deaths of children under five years of age, by months, was as follows: —

January,	179	July,	313
February,	158	August,	340
March,	167	September,	213
April,	169	October,	133
May,	146	November,	128
June,	141	December,	147

The months having the greatest number of deaths of this class were July, August and September, and those having the least number were June, October and November. The deaths in the third quarter were nearly twice as great as those in either of the other quarters.

Consumption.

The number of reported deaths from consumption was 3,238, and the weekly average was 62. The greatest number of deaths reported from this cause in a single week was 85, in the week ending January 9, and the least number was 41, in the week ending September 10.

The average weekly number of reported deaths from this cause in each month was as follows: —

January,	75	July,	59
February,	54	August,	58
March,	61	September,	51
April,	69	October,	57
May,	62	November,	58
June,	57	December,	61

The months having the greatest number of deaths from this cause were January and April, and those having the least number were February and September.

The following table presents the variations from the weekly average number of deaths for the past four years: —

	1889.	1890.	1891.	1892.		1889.	1890.	1891.	1892.
January,	0	42	4	13	July,	—1	—8	—4	—3
February,	4	3	—4	—8	August,	—1	—4	—3	—4
March,	0	3	—5	—1	September,	—3	—5	—3	—11
April,	2	1	4	7	October,	0	—11	3	—5
May,	—1	1	6	0	November,	1	—12	—4	—4
June,	—2	—3	—2	—5	December,	0	0	5	—1

The ratio of reported deaths from consumption to the mortality reported from all causes was 111.33 per 1,000, while that of previous years was as follows: —

1886,	156.5	1890,	130.0
1887,	141.1	1891,	116.5
1888,	134.2	1892,	111.3
1889,	125.0		

The ratio to the reporting population in 1892 was 2.35 per 1,000, as compared with 2.42 in 1891.

Acute Lung Diseases.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 3,951, and the weekly average was 74. The greatest number of deaths reported from this cause in a single week was 263, in the week ending January 16, and the least number 13, in the week ending August 20. The deaths from these causes in the weeks ending January 2, 9 and 16 were nearly the same, and were respectively 245, 260 and 263. Those for the last two weeks of August and the first week of September were also nearly the same, namely, 13, 14 and 16.

The average weekly number of reported deaths from these causes for each month was as follows: —

January,	214	July,	26
February,	104	August,	20
March,	89	September,	31
April,	91	October,	37
May,	79	November,	61
June,	41	December,	80

The months having the greatest number of reported deaths from these causes were January and February, and those having the least number were July and August.

The ratio of reported deaths from acute lung diseases to the reported mortality from all causes was 135.7 per 1,000.

The estimated death rate per 1,000 of the reporting population from these causes was 2.82, as compared with 2.69 in the previous year.

Typhoid Fever.

The total number of reported deaths from this cause in 1892 was 441, and the average weekly number was 8. The greatest number reported in any single week from this cause was 21, in the week ending September 24, and the least number was 1, in the week ending July 2.

The average weekly number of deaths reported from this cause for each month was as follows: —

January,	6	July,	6
February,	5	August,	9
March,	7	September,	11
April,	4	October,	37
May,	5	November,	11
June,	5	December,	12

The months having the least number of deaths from this cause were February, April and June, and those having the greatest number were October and December. The numbers of deaths from this cause in the first seven months of the year were fairly uniform.

The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 15.15 per 1,000, and the ratio to the reporting population was .31, as compared with .38 in the previous year.

Diphtheria and Croup.

The total number of reported deaths from diphtheria and croup in 1892 was 928, and the average number in each week was 18. The greatest number reported in a single week from these combined causes was 39, in the week ending December 31, and the least number was 3, in the week ending August 27.

The average weekly number of reported deaths from these causes for each month was as follows: —

January,	24	July,	10
February,	15	August,	8
March,	20	September,	10
April,	19	October,	16
May,	21	November,	24
June,	13	December,	27

The months having the greatest number of reported deaths from these causes were January, November and December, and those having the least number were July, August and September. The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 31.9 per 1,000, and the death rate as compared with the reporting population was .66 per 1,000, that of the previous year being .49.

Scarlet-fever.

The reported deaths from scarlet-fever in 1892 were 446, and the average weekly number was 8. The greatest number of reported deaths from this cause in a single week was 15, in the weeks ending November 12 and December 17, and the least number reported in a single week was 1, in the week ending September 17. The average weekly number reported in each month was as follows: —

January,	9	July,	4
February,	9	August,	4
March,	9	September,	2
April,	11	October,	7
May,	12	November,	11
June,	8	December,	12

The months having the greatest number of deaths from this cause were May and December, and those having the least were August and September. The disease appears to have prevailed with a more than usual uniform severity throughout the year, the least number

of deaths being in the third quarter. The ratio of deaths from this cause to the reported deaths from all causes was 15.3 per 1,000, and the death rate of the reporting population from this cause was .32 per 1,000, as compared with a much smaller rate in 1891, namely, .1 per 1,000.

Measles.

The total number of reported deaths from measles in 1892 was 38, and the weekly average was less than one. The greatest number of deaths reported from this cause in a single week was 4, in the weeks ending May 21 and June 18. There were also twenty-nine weeks in which no deaths from measles were reported. June and December were the only months in which the average weekly number of reported deaths from this cause was more than one. The ratio of deaths to the reported mortality from all causes was 1.3 per 1,000, and the death rate from this cause was .03 per 1,000 of the reported living population, as compared with .07 in 1891.

Diarrhœal Diseases.

The diseases included in this group are diarrhœa, dysentery, cholera morbus and cholera infantum. From these causes combined the number of deaths reported in 1892 was 2,143, and the weekly average number was 40. The greatest number reported in a single week was 355, in the week ending July 30, and the least number was 1, in the week ending February 27.

The average weekly number of reported deaths from these causes in each month was as follows: —

January,	5	July,	172
February,	2	August,	200
March,	7	September,	80
April,	5	October,	20
May,	9	November,	10
June,	16	December,	4

The months having the greatest number of reported deaths from these causes in 1892 were July, August and September, and those having the least were January, February and December. The deaths from these causes in the third quarter of the year constituted 85 per cent. of the number of deaths from the same causes for the entire year. The ratio of reported deaths to the reported mortality

for all causes was 80 per 1,000, and the death rate of the reporting population from these causes was 1.66 per 1,000, as compared with 1.82 in 1891.

Whooping-cough, Malarial Fever, Erysipelas, Puerperal Fever and Small-pox.

The essential statistics relating to these five diseases are embraced in the following table: —

	Total Deaths Reported.	Weekly Average.	Ratio per 1,000 of Reported Deaths from All Causes.	Ratio per 1,000 of Estimated Population.
Whooping-cough,	121	2.3	4.2	.08
Erysipelas,	74	1.4	2.5	.05
Puerperal fever,	51	1.0	1.7	.04
Malarial fever,	13	.25	.4	.01
Small-pox,	2	-	-	-

Whooping-cough presented a greater mortality in the first half of the year than in the last half. The reported deaths from this cause for the first three months of the year were 38 per cent. of the yearly total, and those of the first six months were 61 per cent. The greatest number of reported deaths from whooping-cough was 7, in the week ending April 30, and there were no deaths from this cause in the weeks ending April 23, October 1 and October 15. The death rate per 1,000 of the reported living population was .08, as compared with .07 in 1891.

That of erysipelas was .05 in 1892, and .06 in 1891; and that of puerperal fever was .02 in 1892, and .04 in 1891. The latter has undoubtedly been reduced to a very small ratio since the introduction of more intelligent preventive measures.

No deaths from malarial fever were reported in the first four months of 1892, and the total number reported in the remaining months was 13 only.

Investigation of Recent Epidemics of Typhoid Fever in Massachusetts.

By WILLIAM T. SEDGWICK, Ph.D.,
BIOLOGIST OF THE BOARD.

ON RECENT EPIDEMICS OF TYPHOID FEVER IN THE CITIES OF LOWELL AND LAWRENCE DUE TO INFECTED WATER SUPPLY;
WITH OBSERVATIONS ON TYPHOID FEVER IN OTHER CITIES AND TOWNS OF THE MERRIMACK VALLEY, ESPECIALLY NEWBURYPORT.

(WITH PLATES AND FIGURES.)

BY WILLIAM T. SEDGWICK, Ph.D., BIOLOGIST OF THE BOARD.

Lowell and Lawrence in 1890 were the largest cities on the Merrimack River. Lowell is in size the third city of Massachusetts, only Worcester and Boston having larger populations. Both cities are on the northern border of the State but by the river Lawrence is nine miles nearer the sea. Between Lawrence and the ocean lie the cities of Haverhill eight miles below Lawrence, and Newburyport at the river's mouth. Between Haverhill and Newburyport is the town of Amesbury. Above Lowell lie, in order, the large New Hampshire cities of Nashua, Manchester and Concord, upon the Merrimack River, and upon the Nashua River (its most important tributary) the city of Fitchburg, and the large town of Clinton, in Massachusetts. A smaller tributary, the Concord, joins the Merrimack at Lowell, and upon this lie the busy manufacturing town of Marlborough and the historic town of Concord, Massachusetts. The location of these cities and towns, with the course of the Merrimack, Nashua and Concord rivers, and a small portion of their immense drainage area, is shown upon the accompanying map. The populations indicated in brackets on the map are estimated for 1892. The returns of the United States Census of 1890 for these cities and towns are as follows: —

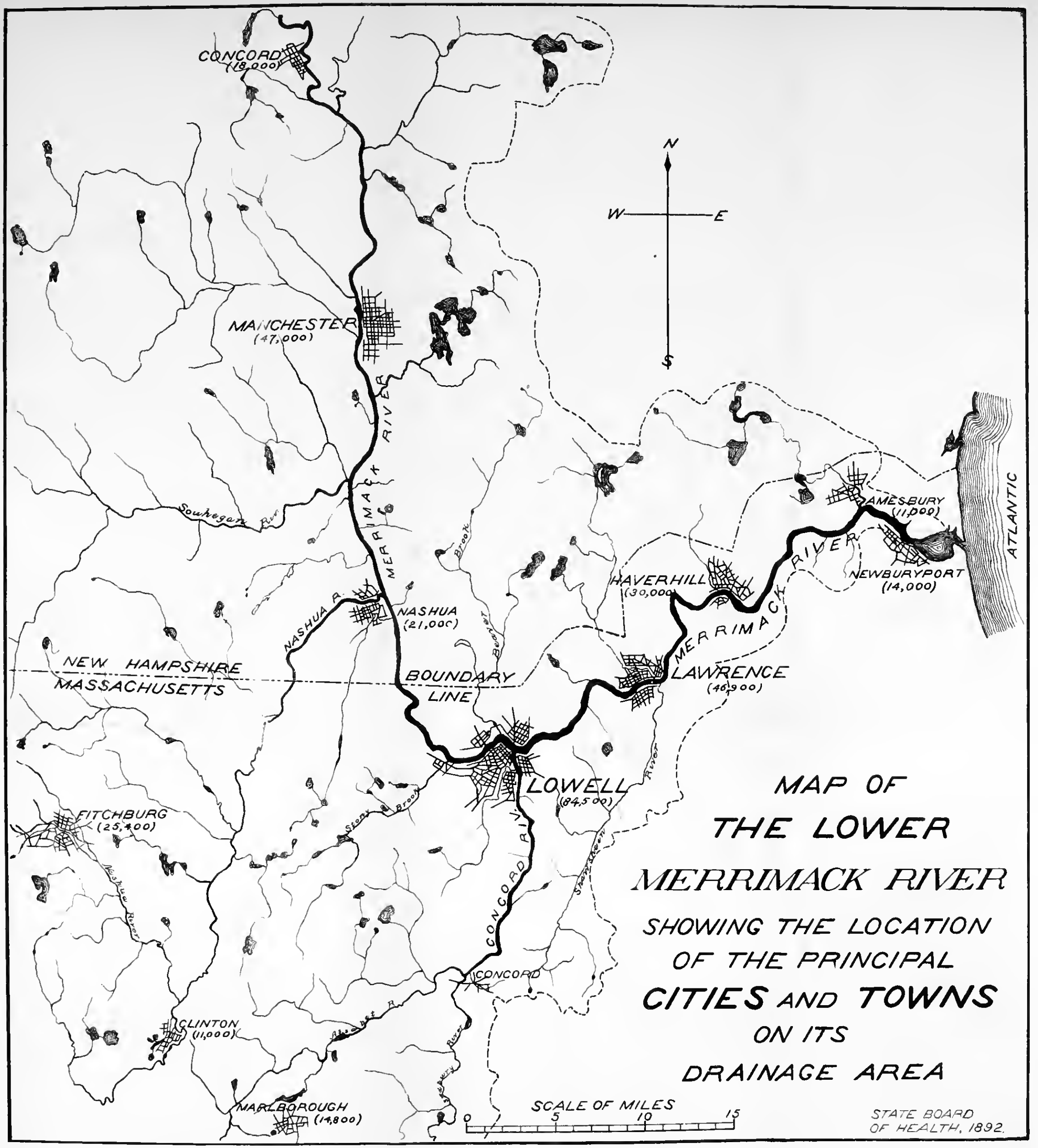
Lowell,	77,696	Concord (N. H.),	17,004
Lawrence,	44,654	Newburyport,	13,947
Manchester (N. H.),	44,126	Marlborough,	13,805
Haverhill,	27,412	Clinton,	10,424
Fitchburg,	22,037	Concord (Mass.),	4,427
Nashua (N. H.),	19,311		

The Lowell Epidemic of Typhoid Fever in 1890–91.

Typhoid fever had already been excessive in Lowell (and Lawrence) as compared with the other towns and cities of the State for many years, as has been shown by Mr. H. F. Mills (see Twenty-second Annual Report, State Board of Health of Massachusetts, for 1890, p. 525); but it had not risen to such proportions as to alarm the citizens until the autumn of 1890, when the attention of the Board was drawn to an unusual prevalence of the disease in Lowell and afterwards in Lawrence, nine miles below.

The gravity of the situation was not recognized during the height of the epidemic, namely, in November. But when, at length, in December it became known that there had been during the preceding month one hundred and twenty-two cases of typhoid fever reported, and twenty-eight deaths from the same disease, or one hundred and one cases and nineteen deaths more than in the same month of the previous year, there was naturally much anxiety in Lowell.

During a part of the previous autumn I had been engaged as a representative of the State Board of Health in a sanitary investigation of certain well waters of Lowell, having personally made a house-to-house investigation covering two small but typical districts of the city, so that I was already somewhat acquainted with the local conditions. I was therefore requested by Mr. Mills, chairman of the committee of the Board on water supply and sewerage, to visit Lowell, and, if possible, discover the cause of the epidemic. At the same time I was urged by the Water Board of Lowell to make a similar investigation on their behalf, inasmuch as it was freely charged and widely believed that it was the public water supply which was at the bottom of the trouble. Accordingly, I began a thorough inquiry and on April 4, 1891 presented to the Water Board of the city of Lowell a full Report, illustrated by maps, diagrams and photographs. The text of this report was soon after published by them, but without the accompanying important and instructive illustrations. (See *A Report upon the Sanitary Condition of the Water Supply of Lowell, Mass., presented to the Water Board of Lowell, April 10, 1891*, pp. 1–54. By William T. Sedgwick. Lowell, Mass., 1891.) An abstract of this report, but also without the necessary illustrations, appeared in the "Boston Medical and Surgical Journal," 1893, pp. 397–402, 426–430. I shall therefore give here only a succinct account of the details of the epidemic in Lowell, and invite the reader's attention more particularly to a new


CONCORD (18,000)
MANCHESTER (47,000)
MERRIMACK RIVER
Souhegan River
NASHUA R.
NASHUA (21,000)
NEW HAMPSHIRE
MASSACHUSETTS
BOUNDARY LINE
Beaver Brook
HAVERHILL (30,000)
MERRIMACK RIVER
LAWRENCE (46,900)
AMESBURY (11,000)
NEWBURYPORT (14,000)
ATLANTIC
LOWELL (84,500)
FITCHBURG (25,400)
Stony Brook
Nashua River
Shawsheen River
CONCORD R.
CONCORD
CLINTON (11,000)
Assabet R.
Sudbury River
MARLBOROUGH (14,800)
N
W
E
S
SCALE OF MILES
0 5 10 15
MAP OF THE LOWER MERRIMACK RIVER SHOWING THE LOCATION OF THE PRINCIPAL CITIES AND TOWNS ON ITS DRAINAGE AREA
STATE BOARD OF HEALTH, 1892.

series of illustrations specially prepared for the present paper under my personal supervision, by Mr. Richard D. Chase. I shall make liberal use of extracts from the text of my report referred to above.

It was easy to find that an epidemic really existed in Lowell. The cases reported and the deaths occurring abundantly established this fact. It was also evident that it was confined to no special locality within the city. The cause, therefore, must be general, and not local. Yet at the beginning no other city in New England was suffering in the same way, so that it was plain that the trouble was endemic with respect to Lowell, and not pandemic either in the Merrimack valley or in New England. Moreover, the epidemic in Lowell was at its height in November and later, a time when the mortality from typhoid fever throughout the State is ordinarily rapidly diminishing, after its annual exacerbation in September and October. (In this connection see the instructive diagram of weekly mortality from typhoid fever in Massachusetts, Twenty-third Annual Report, for 1891, p. 728.) Popular opinion attributed the trouble to the drinking water supplied by the city; but against this theory it was urged that if this were the case, Lawrence, on the river below, should also be suffering, since, like Lowell, it derived its public water supply from the Merrimack River; and at the start Lawrence was comparatively exempt from typhoid fever. It was also alleged with boldness that "many" of the victims of the disease had drunk no city water, but either no water at all or well water or spring water. It was even denied by some that the prevalent disease was typhoid fever, and it was also asserted that "many" of the cases reported as typhoid fever were really of "some other disease," or even non-existent. Meantime, the newspapers contained lengthy accounts of the epidemic, and various local authorities were cited for all kinds of opinions regarding the cause of the trouble.

I immediately began a house-to-house visitation of the reported cases, in order to ascertain personally and positively the real state of affairs. Having satisfied myself by actual observation that a severe epidemic existed, and that it was unquestionably an epidemic of typhoid fever, I devised a suitable record blank, to be filled out for each case, and resigned the larger part of the canvassing to my trusted assistant, the late Mr. George V. McLauthlin, who carried on the work with remarkable enthusiasm, persistence and ability. The record blank used for this epidemic has proved exceedingly valuable in other similar investigations, and as finally perfected is exhibited in form (but not exactly in size) on the next page.

*

State Board of Health of Massachusetts.

TYPHOID FEVER.

Date { *Of taking to bed,* ____
Of physician's first visit, ____

Name, ____ *Age,* ____

Street and No. (when taken ill), ____

Present address, ____

Place of work, business or school, ____

Physician while ill, ____

Health before attack, ____

Out of town, ____

Length of illness, ____

Chills, ____ *Nosebleed,* ____

Vomiting, ____ *Diarrhœa,* ____

* *Headache,* ____ *Tongue,* ____

Fever, ____ *Delirium,* ____

Pain in bowels, ____ *Eruption,* ____

Drinking Water. { *City,* ____ *Filter,* ____
Canal, ____
Spring, ____ *Well,* ____

Milk, ____ *Milkman,* ____

Previous cases in house, ____

Other cases near by, ____

Privy or W. C. ____ *Plumbing,* ____

Remarks, ____

* ____

____

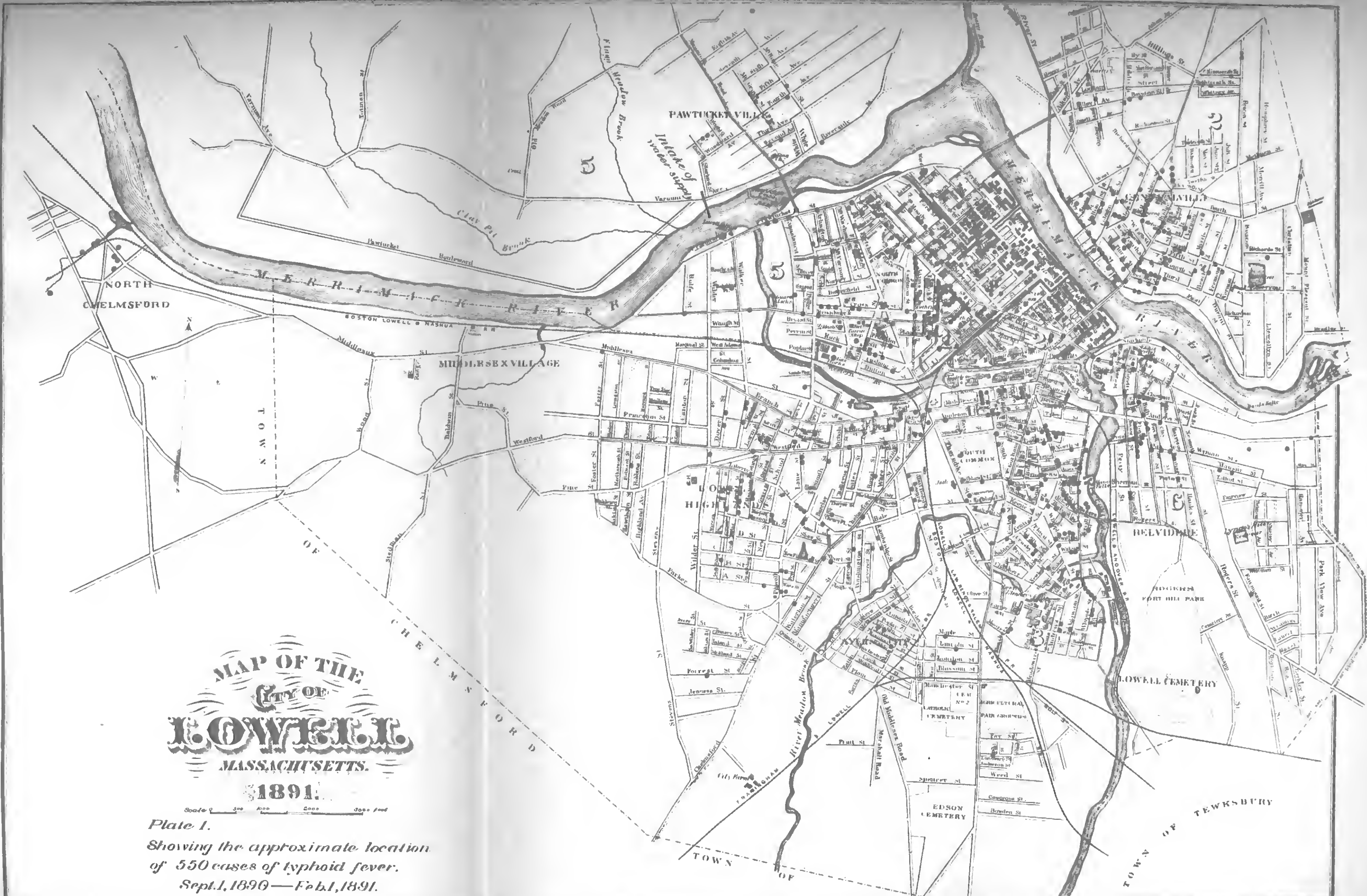


Plate I.
Showing the approximate location of 550 cases of typhoid fever.
Sept.1, 1890—Feb.1, 1891.

The actual size of the blanks now in use (1893) is $9\frac{3}{8} \times 6$ inches, and they are perforated by three holes punched near the left-hand margin (and here indicated by stars). By means of these holes the sheets can be temporarily (or permanently) bound together; and it has been my practice of late to fasten them between similarly perforated stiff covers by means of brass fasteners, carrying every day during an inquiry only enough for that day, and changing the supply at night. It is highly important to have each case recorded on a *separate* slip or card of this sort, in order that the cases may be arranged in various combinations for study.

In most epidemics of typhoid fever, the fixing of the precise *time* of infection is of supreme importance for the investigator, and this may often be obtained with considerable accuracy by the date of the physician's first visit or the time of the patient's taking to bed. The former can usually be got from the attending physician; the latter, in a surprising number of cases with tolerable accuracy, from the patient or his friends. The location of the patient when attacked is also highly important, as possibly indicating the *place* of infection, the place of work, business or school giving alternative information of the same nature. The symptoms are asked for partly as a matter of routine, partly to get the patient or his friends to talk and so disarm suspicion, and partly for use when it is denied that the epidemic is real. The other items upon the blank require no comment.

Having satisfied myself (1) that there was really an epidemic of typhoid fever in Lowell; and (2) that most, if not all, of those affected had been (as would naturally be the case in any epidemic) users of the city water; and finding, moreover, that the epidemic was apparently confined to no one locality, and was therefore presumably due to some cause of a very general kind, I turned first to the water supply as the most promising possible source of the disease.

Five Systems of Water Supply in Lowell.

The investigation had hardly begun before I discovered that the problem was unexpectedly complicated by the existence in Lowell of five distinct systems of water supply, of which two are obviously polluted by sewage within the city itself.

The *principal* supply is the city water, drawn partly from the filter-gallery in Pawtucketville, but chiefly, and without any attempt

at purification, from the Merrimack River. The water from the river mixes with that from the filter-gallery in the gate-house at Pawtucketville, and is afterward pumped to reservoirs, from which it is distributed to all parts of the city.

A *second* system is that owned by the Proprietors of Locks and Canals on Merrimack River, and is chiefly used for fire purposes and for the feeding of boilers. It is also used, however, to a small extent, for drinking purposes. The supply for this system is drawn from the Merrimack canal through the penstock of the Lowell Machine Shop, and is then pumped to a small reservoir on Lynde's Hill, in Belvidere, from which it flows to a few houses, and to most of the mills situated upon the canals fed from the Merrimack River. It will be shown beyond that this water is much polluted.

The *third* system is also supplied by canal water, and, although intended chiefly for washing purposes, this water is, in fact, used to some extent for drinking. It is still more polluted than the Lynde's Hill supply.

The *fourth* system is the supply derived from wells. Many of the wells that formerly existed in Lowell have been closed or abandoned, but some of questionable purity are still in use. Some of the mills are supplied with well water, which in such cases is usually brought and kept in wooden pails, for drinking purposes.

The *fifth* system is that of the so-called spring waters, which are publicly sold for drinking purposes.

The Principal and Public Water Supply: "City" Water from the Merrimack River.

As has already been stated, the principal and public water supply of Lowell, the so-called "city" water, is drawn, in part, from a covered filter-gallery, on the northern bank of the Merrimack River above the dam, and, in part, directly from the river, at a point near the lower end of the filter-gallery and several hundred feet above the dam. The position of the intake is shown in red upon Plate No. I. The river water is received directly at the point of intake through a thirty-inch pipe, and, after having mingled with a much smaller volume of water from the filter-gallery, flows to the pumping station on West Sixth Street, from which it is pumped to the reservoirs, both high service and low service. There was, however, a difference in the method of filling these reservoirs.

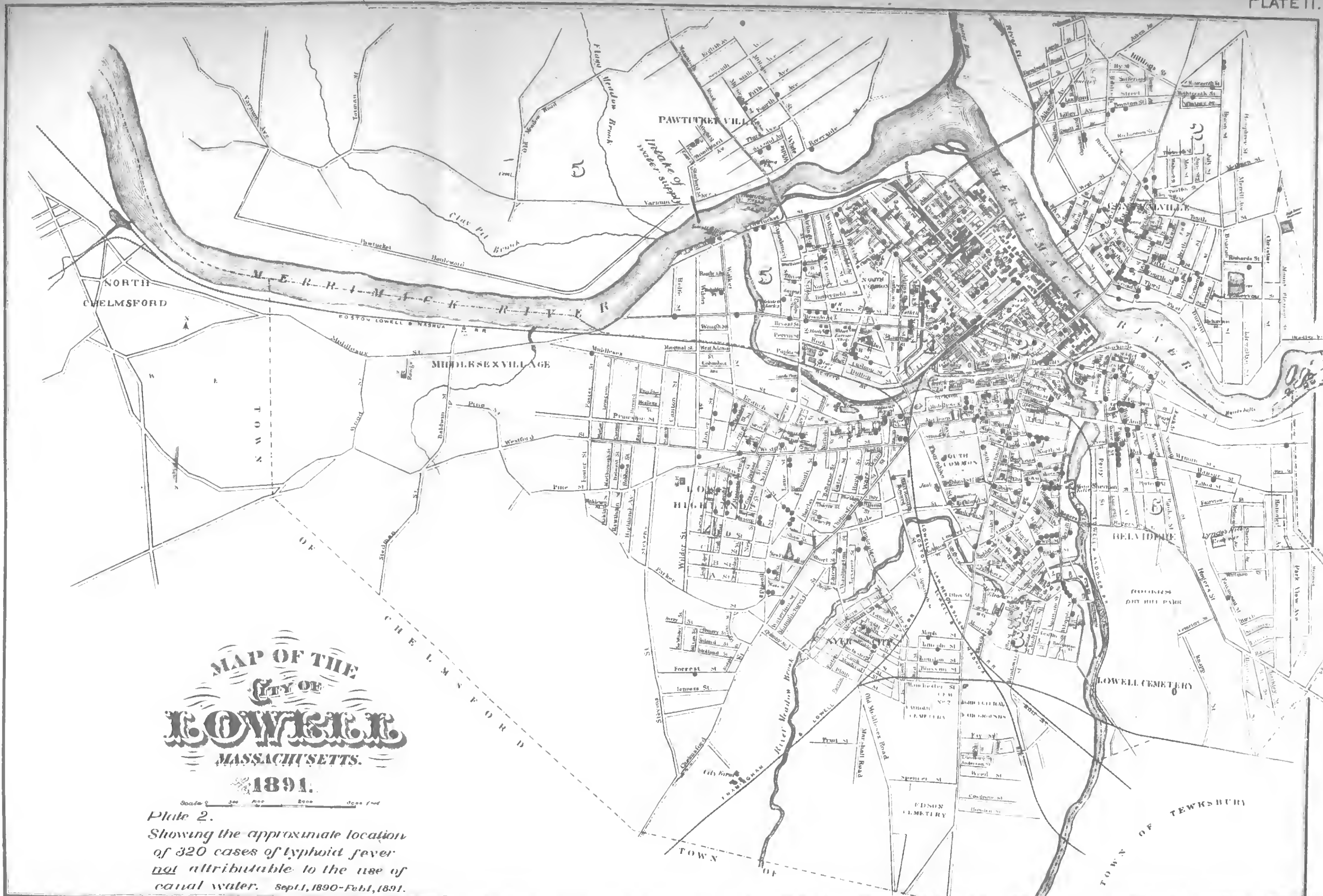


Plate 2.
Showing the approximate location of 320 cases of typhoid fever not attributable to the use of canal water. Sept.1, 1890–Feb.1, 1891.

Most of the city is connected with the low-service reservoir, from which, therefore, there is constantly flowing a large stream of water, and into which a correspondingly large stream must be pumped. Moreover, for several months previous to the date of my report, the outflow had been taken from a point very near the mouth of the inflow pipe, so that much of the water could have remained in the reservoir only a short time before being delivered at the nearer city taps.

The high-service reservoir, on the other hand, supplied but very few people, comparatively speaking, namely, about eighty houses in Centralville, and seventy in Belvidere. Although it is a much smaller reservoir, the draft upon it is small, owing to the few houses connected with it, and it was therefore filled only about once a week, but oftener if necessary. During the interval the water has an opportunity to settle and otherwise change, until, the contents having become drawn down somewhat, a fresh supply is pumped in and mingles with that already present.

The high-service tap water is usually better, both chemically and bacteriologically, than that of the low service; and there is reason to believe that this is due, in part, to its longer storage, which gives it an opportunity to settle and otherwise change, and in part to its longer stay in the pipes.

The Indirect Canal Water Supply, *via* Lynde's Hill Reservoir.

The Lynde's Hill Reservoir system is used chiefly for fire purposes and for the feeding and cleaning of boilers in those mills to which it is distributed, namely, the principal mills supplied with water power by the Proprietors of Locks and Canals. Owing to the fact that this system was introduced into Lowell before the public water supply, a few houses, belonging chiefly to members of the Locks and Canals Corporation, or to the corporation itself, are still supplied with this water, as is also the office of the corporation on Broadway.

I was able to discover only one case of typhoid fever upon this system, and that not far from the reservoir, on Andover Street.

A. D., an Irish girl, eighteen years old, arrived in New York from Ireland, on Oct. 24, 1890. She came directly to Lowell, and from the time of her arrival drank freely of water from the Lynde's Hill

Reservoir. She fell ill on November 21, went to St. John's Hospital, and had a well-defined case of typhoid fever. She might have drunk city water or other water, or milk, during visits to friends; but she was positive that she never did so. There was no occasion to suspect the milk supply or anything else connected with the case, so that I consider it highly probable that the disease was caused by the use of Lynde's Hill water, particularly as this is known to be polluted with sewage from many sources.

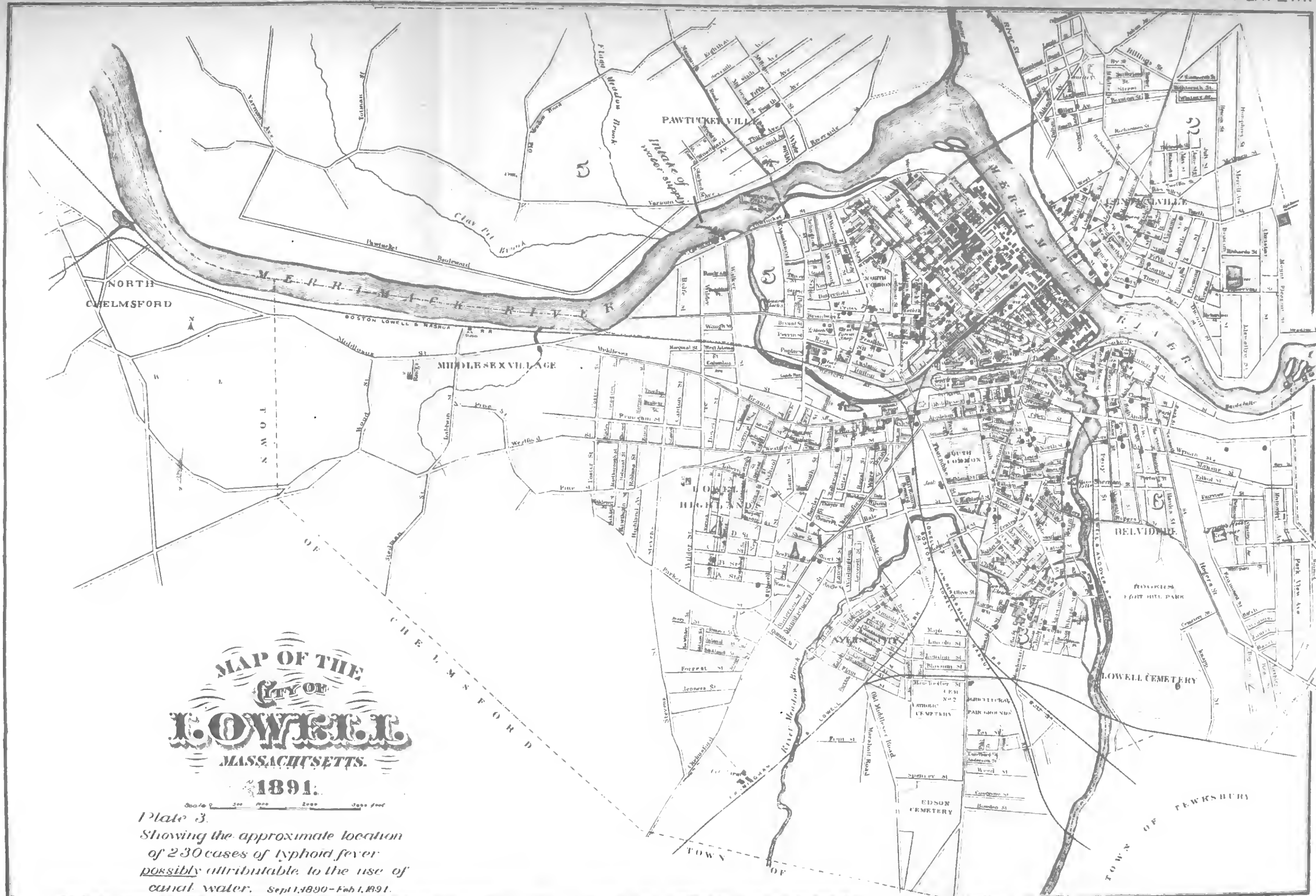
This water was drawn from the Merrimack Canal at the Lowell Machine Shop, in the heart of the city. The water of the Merrimack Canal is derived mainly from the Pawtucket Canal, but it receives also some water from the Northern Canal through the Western. The Pawtucket Canal must ordinarily receive most of the discharge of the Walker Street sewer, which empties into the Merrimack River just above the place of origin of the Pawtucket Canal. Similarly, into the Northern Canal most of the contents of the School Street sewer must pass, since this empties into the river just above the place of origin of the Northern Canal. Furthermore, it is known that there were upon the Pawtucket Canal at least eight privies or water-closets; upon the Western three or more. Moreover, all the drainage from certain factories employing more than two hundred hands was poured directly into the Western Canal; while the Northern Canal received directly the sewage of the water-closets of the Lowell Hospital. Finally, three large overflows from the main city sewers empty, two into the Pawtucket and one into the Western Canal.

In view of all these facts, it must be reckoned a fortunate circumstance that so little of this water was used for drinking purposes, although, as will shortly appear, from its source in the upper instead of the lower canal, from the length of the service, the storage in the reservoir, etc., it was probably far less objectionable than the direct canal water supply, which was accessible for drinking in many of the mills.

The Direct Canal Water Supply.

More than one-fourth of the population of Lowell was in 1890 employed in the mills. Their homes were scattered about the city, although many lived in the vicinity of the mills or in the so-called "corporation" boarding-houses.

Most of the mills were furnished with drinking water drawn from


MAP OF THE
CITY OF
LOWELL
MASSACHUSETTS.
1891.
Plate 3.
Showing the approximate location of 230 cases of typhoid fever possibly attributable to the use of canal water. Sept 1, 1890 - Feb 1, 1891.
MERRIMACK RIVER
NORTH CHELMSFORD
MIDDLESEX VILLAGE
PAWTUCKETVILLE
Intake of water supply
BELVIDERE
LOWELL CEMETERY
EDSON CEMETERY
TOWN OF CHELMSFORD
TOWN OF TEWKSBURY

wells or from the city supply. In the majority of cases the several rooms of the mills were supplied with drinking water by means of wooden pails, in which water was brought by hand from some tap of city water, or from some well, either in the mill itself, or in the mill yard, or in the immediate vicinity of the mill. In a few cases only, for example, in the "Merrimack" Mills, city water was said to have been introduced into every room. In the "Hamilton" Mills a special tank of large size had been built, into which city water was run. The tank was so large that, in summer, ice, in cakes, was easily introduced at the top. At the bottom of this reservoir was a series of taps, to which messengers were sent, when necessary, from the various rooms. These mills, therefore, were provided with an abundance of city water, properly cooled in summer.

The "Massachusetts" Mills had a well conveniently placed in their spacious yard. The "Boott" was supplied from wells in the neighborhood. The "Lawrence" had a similar source of supply. The "Tremont" and "Suffolk" obtained their drinking water from a tap on the city service. The Lowell Machine Shop had one city tap, but depended chiefly on a well in the mill yard. The mills on the Concord River Canal also used, in some cases, well waters, supplying the several rooms by pails.

It appears, therefore, that with a few exceptions the mills were not piped for city water. There is, nevertheless, in most of the mills in Lowell a complete system of water supply, although it is not intended to serve for drinking purposes. This is the canal water, which is drawn, by nearly every mill situated upon a canal, directly from the wheel pit, and pumped to a tank at the top of the mill. From this it flows by gravity to all parts of the mill, supplying, for example, the water for the water-closets, for washing, for atomizing, etc., in short, for all purposes except for drinking. In many, perhaps in most, of the rooms this water was delivered by faucets of the ordinary pattern, projecting, as usual, above large sinks. It was generally the most accessible, and sometimes the only easily accessible, water; and this circumstance, added to the fact that it was often cooler than the pail water, which had perhaps been standing for some time in a heated room, tempted the indifferent or careless to use it for drinking. I have abundant evidence that it was often used for drinking and was sometimes preferred to the pail-water supply. I have myself seen a drinking cup hanging upon a

canal-water faucet, and I discovered one overseer who himself so much preferred the polluted canal water for drinking that he said that he did not want to have any other water in the rooms under his care. In the statistics of the cases of typhoid fever given beyond, it is shown that some freely admitted that they had frequently drunk canal water. It was also alleged, with some show of probability, that the bobbin boys sometimes detailed to keep the pails filled with drinking water, occasionally, in order to avoid a longer journey, went to another room and there filled the drinking-water pail with canal-water. Again, I have myself seen drinking-water pails standing entirely empty, apparently from oversight or neglect, and I have also occasionally seen operatives drawing and drinking canal water.

These various circumstances proved indubitably that some canal water was used for drinking; and when I brought out this fact, the defenders of the city water urged that here, then, probably was the source of the epidemic.

The exact quality of the canal water varies with the situation of the mill. Some of the mills are upon the "upper level," *i. e.*, receive canal water from the Pawtucket, Northern, Western and Merrimack canals. Others are upon the "lower level," *i. e.*, receive canal water which, originally drawn from the Merrimack River, has already passed along the canals just named and through the mills upon the upper level, and is now used over again by mills on a lower level before it finally passes into the river still further down. Some overflow water from the upper canals also feeds the mills on the lower level, without having passed through the mills above; but the mills upon the lower level necessarily use mostly canal water which has already passed through the mills on the upper level.

The sources of pollution of the water of the upper canal have already been described in the previous section. We have only to reflect, first, that all of the mills on the upper level are directly supplied with the polluted water of the upper canal; and, second, that this water, further defiled by all the sewage from many large mills, is afterwards similarly used by the mills on the lower level, in order to realize the dangers to which drinkers of this water, especially in the mills on the lower level, are exposed. This is more emphatically the case during an epidemic of typhoid fever in the city, when the excreta from many cases, especially mild cases and cases in the early stages of the disease, poured in from the sewers on Walker and

Fig. A. Stony Brook, North Chelmsford, showing in the foreground Tail Race of Woolen Mill, Point of Infection by Cases No. I and II; in the background. Privy of Foundry, Point of Infection by T. L., (Case No. IV.)

School streets, further enriched by the discharges from the Lowell Hospital and from various privies, and finally added to the excreta from thousands of workers in the mills on the upper level, must have infected the canal water. It should certainly be counted a most fortunate circumstance that the canal water was not more generally used for drinking purposes.

As soon as I had brought to light these unexpected facts concerning canal water, I notified the local board of health, who immediately caused proper placards to be posted in the mills warning the operatives against the use of the canal water for drinking.

Probably the most curious fact developed during the whole inquiry was the discovery that the Lowell Hospital was emptying its sewage directly into the Northern Canal, water from which was, in the manner described, accessible for drinking to thousands of people.

The Well-water Supply.

There are still many wells in use in Lowell. This is more true, however, of the summer time than of the winter. On account of their greater coolness, well waters are much resorted to in summer, especially by those who have no ice. In winter they are but little used, comparatively speaking, and, as I had been studying certain much-used wells in Lowell in August and September, I had personal and accurate knowledge of the conditions at that season.

In point of fact, some of the wells most resorted to in July and August were almost completely neglected before October 1, and, as I have reason to believe that this was true of most of the wells of the city, I am convinced that the wells could not have been the principal factor in the epidemic of typhoid fever. On the contrary, the epidemic was severest in November, *i. e.*, at a time when the use of well water for drinking purposes had virtually been given up for the season, and the drinking of city water had become, once more, almost universal. I consider it possible that a very few of the cases generally believed to be due to the use of city water or canal water might have been caused by polluted wells, but I failed to find any evidence of it.

In the investigation of the cases of typhoid fever a few were found in which well waters had been used, besides those among the attachés of the mills, who, as we have seen in the previous section, drink much well water. At the same time it was fully proved and will

be shown beyond that, even if polluted canal water had been inoperative, and all mill cases had been due to polluted well water (which we can by no means suppose to be true), there yet remained in the city a notable epidemic among those who had not drunk either canal water or well water, but only the city water.

The Spring-water Supply.

This, the fifth source of water supply in Lowell, was, comparatively speaking, of minor importance. There were four waters publicly sold in the city as "spring" waters. These I carefully examined, both chemically and bacteriologically. I found no evidence, however, either in the results of these analyses or in the history of the cases of typhoid fever in the city, that spring waters had had anything to do with the causation of the epidemic. I do not know to what extent these "spring waters" had been used, but I found no evidence whatever that any number of persons who had drunk spring water exclusively had been attacked by typhoid fever. Two or three cases were met with in which spring water was chiefly used, but even these were extremely rare.

Conditions to be fulfilled by any Water-infection Theory of the Epidemic.

Five distinct systems of water supply in Lowell have now been described. With respect to three of these I found no evidence which made further investigation necessary. The epidemic of typhoid fever in 1890 was not attributable to the Lynde's Hill Reservoir supply, or to the well-water supply, or to the spring-water supply. If caused by drinking water of any kind, it must have been by canal water, or by city water, or by both. We have seen that the canal water was so extensively polluted as to suggest that the entire epidemic might possibly have sprung from this source, and this possibility was accepted by some as a sufficient explanation of it. A little reflection, however, was enough to show that even upon this hypothesis it still remained to explain why there was more typhoid fever from this source this year than usual. And, similarly, if the epidemic were to be laid at the door of the city water, it became absolutely necessary to the validity of the hypothesis to show why the city water was worse this year than in other years; and particularly why and how it was worse just before and during

Fig. B Privy of Foundry, overhanging Stony Brook, North Chelmsford, a Feeder of the Water Supply of Lowell.
Point of Infection by T. L., (Case No. IV.)

the epidemic than, for example, in July or August when it was probably quite as much used.

I have already observed that the canal water, like the city water, is drawn from the Merrimack River just above the dam (see the canals on Plates I, II, III), so that the double necessity of showing *special infection* as opposed to general and regular pollution was really reduced to one; namely, some sufficient and also unusual condition of the Merrimack River not merely with respect to sewage pollution but with respect to typhoid-fever infection.

Discovery of the Probable Cause of the Epidemic.

As soon as it was suspected that the water of the Merrimack River had been the vehicle of the specific infection which caused the epidemic, I set to work to find if there had been any special or unusual infection of the river above Lowell; and was immediately rewarded by the discovery that in the village of North Chelmsford, only three miles above, there had lately been a severe outbreak of typhoid fever, such as had not occurred there before for forty years. Dr. Abbott, the secretary of the State Board of Health, made the same discovery a few days earlier; and I was fortunate in finding the local physician of North Chelmsford, the late Dr. N. B. Edwards, possessed of all the important facts of the case.

In the village of North Chelmsford, which is almost a suburb of Lowell (as may be seen by reference to Plate I), there appeared on July 27, 1890, a case of illness which, although apparently not well defined, must, I think, in view of the phenomena which succeeded it, be regarded as a mild case of typhoid fever. The patient had been working in a wool-scouring mill at North Chelmsford which employs many hands and drains almost directly into Stony Brook, a small and often very foul stream emptying into the Merrimack at a point just above the North Chelmsford railroad station, about two and one-half miles above the intake of the Lowell water works, but on the opposite side of the river (see Plate I). The patient is positive, however, that she had no diarrhœa while at work in the mill, and, as the case is at best a doubtful one, it need not be further considered.

On August 24, Dr. Edwards was called to visit a case of illness which proved to be well-defined typhoid fever. This patient (S. M.), fourteen years of age, had also been working in the wool-scouring

mill, but I am told that she had no diarrhœa while there, although she had other well-marked prodromal symptoms. We may designate this case as Stony Brook Case No. I. Case No. I. worked in the mill regularly until August 23, inclusive, when she went home and was ill for weeks with typhoid fever. There was probably no contamination of the brook, however, by this patient during her home illness, or by any other of the Stony Brook patients while they were at home. Their contamination of Stony Brook ceased, in every case, as soon as the patient was obliged to quit work and to stay at home, because the houses in North Chelmsford have privies not connected with the river.

Another patient, sixteen years of age, who had been working regularly in the woolen mill until September 6, inclusive, fell ill. She was first seen by Dr. Edwards on September 9, and the case proved to be well-defined typhoid fever. This patient (M. A. S.) we may designate as Stony Brook Case No. II.

On October 30, Dr. Edwards was called to a severe case of typhoid fever, namely, that of a young man (T. L.) who had been working regularly until and including October 27, in the North Chelmsford Iron Foundry. While there, and especially on October 25 and 27, this patient, whom we may designate as Stony Brook Case No. IV., used the foundry privy which directly overhangs Stony Brook (see photographs, Fig. A and Fig. B). On the days just mentioned, although the patient was extremely ill and ought not to have tried to work, he did so nevertheless, but was affected by a diarrhœa so severe that he was compelled to resort repeatedly to the privy, and necessarily during those two days spent most of his time there. This patient soon after died.

Nearly a month before this time, a brother of Case No. IV. (J. L.), a workman at the ice-houses of the Boston Ice Company at North Chelmsford, further up on Stony Brook, fell ill, and appears to have had a mild case of typhoid fever. He consulted a physician in Lowell, and reports that the physician pronounced the case to be typhoid fever; but, as he made but one office visit, and consulted no other physician, the diagnosis may be considered incomplete. I am satisfied, however, that this patient, whom we may designate as Case No. III., had a mild case of typhoid fever, and his mother, one sister and two brothers, with whom he lived, appear also to have had typhoid fever. With the exception of the brother (Case

Fig. ... Stony Brook, North Chelmsford, a Feeder of the Water Supply of Lowell. Privy of the Machine Shop

No. IV.), already mentioned, none of the other members of the family appear to have contaminated the brook.

Case No. III. used often, just before his illness, a privy near the ice-houses, overhanging Stony Brook. The position of this privy is shown upon the photograph (Fig. D). The exact date of his illness I have not been able to ascertain, but it is certain that the prodromal period, during which only the privy was repeatedly used, was somewhere between September 23 and October 9.

The epidemic at North Chelmsford, if such it may be called, was confined to three families, and affected, in all, eight or nine cases (one of these being fatal), but only four cases appear to have infected the brook. The points of infection of Stony Brook by Cases No. III. and No. IV. have already been indicated, and are shown upon the photographs. The tail race of the wool-scouring or woolen mill, through which all sewage from the mill enters Stony Brook, is also shown on the photograph (Fig. A). This is, therefore, the point of infection by Cases No. I. and No. II. Fig. C shows another privy, on the bank of the same stream, just above the privy of the Iron Foundry. It is that of the "Machine Shop" of North Chelmsford, and, although it is not known to have inflicted any damage hitherto, it evidently stands in a menacing position.

If, now, we observe the dates of probable infection of the river by these cases, allowing two weeks in each case to cover the period before they stopped work, we shall find that they bear a direct and unmistakable relation to the period of the epidemic. The most important case was Case No. IV., in which we have direct and positive evidence of repeated and extensive infection of Stony Brook, a near feeder of the Merrimack River the source of the public water supply of the city of Lowell, by typhoid-fever excreta, in an early stage of a severe case of the disease.

Inquiries further up the river and its tributaries revealed not more, but rather less, than usual of typhoid fever in the upper Merrimack valley. The same fact has been proved by careful statistical studies (see tables beyond). The Merrimack River is regularly polluted above Lowell, not only by Stony Brook but very extensively by the large cities of Nashua, Manchester, Concord and Fitchburg, the sewers of all of which pour their raw contents directly into the Merrimack River or the Nashua. This they had been doing for months and years; and to the fact that Lowell has been willing to

drink this regularly polluted water, totally unpurified by filtration, is chargeable the fact that typhoid fever has annually been excessive in that city. But the conditions were no worse than usual in these cities in September and October, 1890. There was, however, as has just been shown, an infection of a small and seemingly insignificant feeder of the Merrimack only two and one-half miles above the intake of the Lowell water works, such as is not known to have occurred there for forty years.

The City Officially Warned.

As soon as the more important of the foregoing facts were discovered, the Board was notified and the citizens of Lowell were officially warned against the use of the Merrimack River water for drinking purposes, in a letter to their mayor, Hon. Geo. W. Fifield, by Hiram F. Mills, Esq., C.E., member of the Board and chairman of its committee on water supply and sewerage. (See Twenty-second Annual Report, State Board of Health, for 1890, p. 530.)

Chemical and Bacterial Examinations.

These were made in the hope of discovering some unusual condition of the river, or of possibly detecting the Eberth bacillus itself. But, as usually happens in typhoid-fever epidemics, the worst was over before the examinations began. The chemical examinations showed nothing that was not already known. The bacterial analyses revealed a noteworthy excess of *Bacillus coli communis* confirming the chemical evidence of the presence of sewage in the city water as drawn from the river, but no Eberth bacilli were found. A discussion of this portion of the investigation appeared in the report already cited, and need not be repeated here.

A House-to-house Investigation of the Reported and Other Cases of Typhoid Fever, with Special Reference to Date, Location, Water Supply, Milk Supply, etc.

While the foregoing inquiries were in progress, the systematic canvass of the reported cases of typhoid fever already referred to was going on. This laborious portion of the work was done under my supervision on the ground, by my trusted assistant, the late Mr. George V. McLauthlin. In order to obtain and preserve systemati-

Fig D Stony Brook, North Chelmsford, a Feeder of the Water Supply of Lowell Privy of Boston Ice Co

Point of Infection by J. L., (Case No. III)

cally all the important data, we devised and used the blank already exhibited. Difficulty was found in tracing some of the cases, inasmuch as the families of the poorest classes change their dwelling-place, or "move," very often. Special difficulty was found with the September cases, but it is believed that the data obtained are, for the most part, correct.

In this way, by house-to-house investigation and by other special inquiry, involving a great expenditure of time and labor, all of the reported cases and all of the fatal cases were carefully studied. In the course of this work many cases never reported came to light, and were also investigated. The total number thus carefully investigated was 550. But we have reason to believe that these were by no means all of the cases which really occurred during the period covered by our investigations.

They are distributed as follows: —

Cases of Typhoid Fever Found and Investigated.

1890, September cases,	47
October cases,	95
November cases,	171
December cases,	159
1891, January cases,	78
Total,	550

The cases reported to the local board of health by physicians during the same period numbered 389.

The location (dwelling-place) of these cases when attacked is shown upon Plate No. I. They are limited to no special section, but appear to follow rather closely the density of population. The high service shows about its due proportion of cases, but it is a fact that nearly, if not quite, all of these also had access to the water of the low service. It is worthy of notice that Middlesex Village, as well as the Town Farm, appears to have been entirely exempt.

Maps were also prepared (but are not here reproduced), proving that the distribution month by month was similar to that shown on Plate No. I.

The relative intensity of the epidemic is exhibited by the diagram of weekly mortality and morbidity to be found further on. Its in-

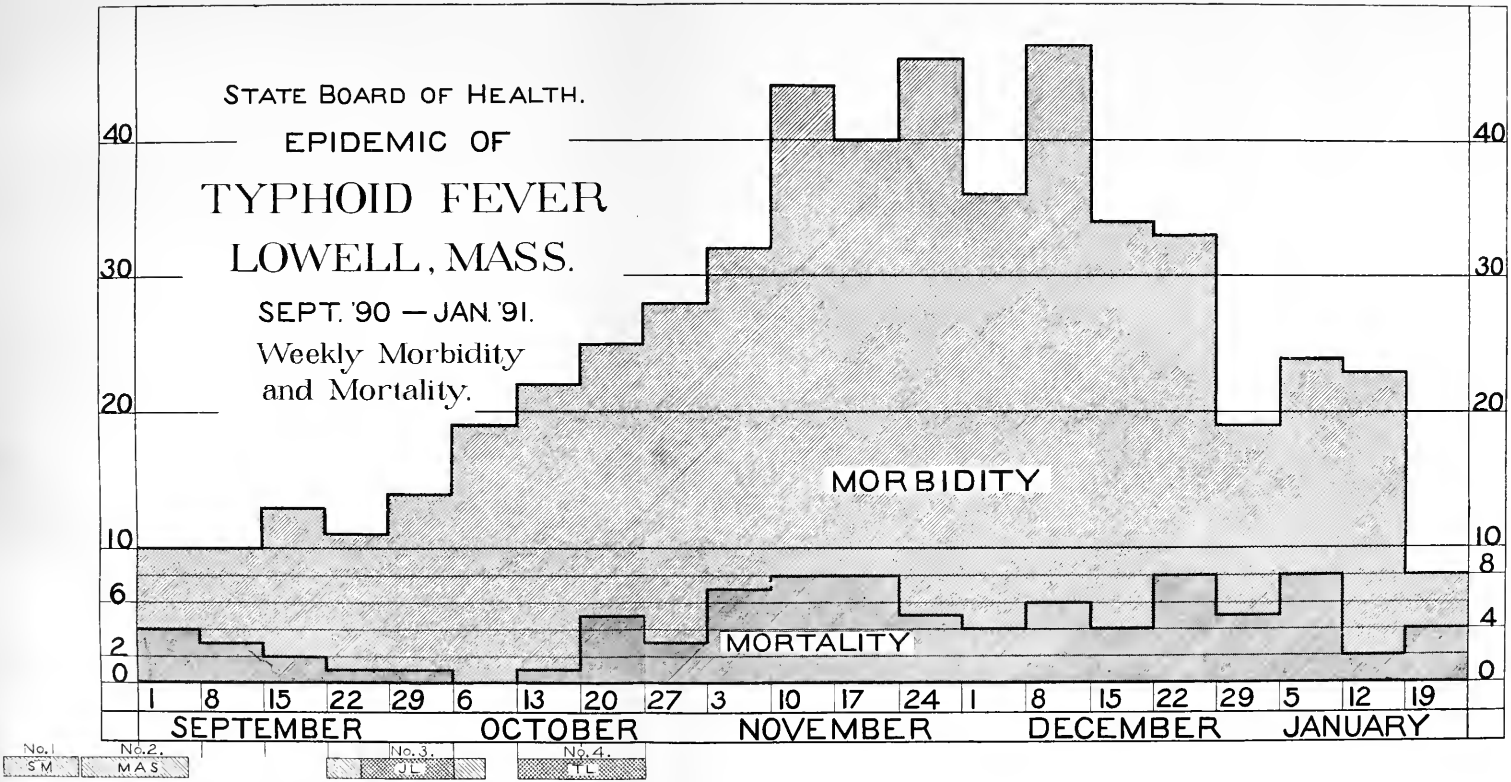
tensity and persistence are manifest. The very heavy mortality of November is especially noteworthy. It is plain that, whatever the infection may have been, it dealt, suddenly, a heavy blow, from which the city was slow to recover.

A more detailed and entirely trustworthy history of the cases, in point of time, was arrived at as follows. In order to fix, if possible, the precise date of infection of each case, I determined to take the date of going to bed as a basis upon which to work, and therefore obtained from each patient (or a friend), when possible, the exact date of illness. This proved entirely satisfactory, since it was usually possible to fix this date with considerable precision. At the end of the investigation these dates were tabulated and plotted, and they have served as a basis for the diagram of weekly morbidity. From this it appears that the mortality was heaviest, and by far the most severe in proportion to the morbidity, early in November. It also appears that the epidemic began in September, rose rapidly during October, and increased very rapidly in the first half of November; after which it fell off, but showed a marked increase every other week. An explanation of this fluctuation will be offered beyond.

Inasmuch as about two weeks are usually required for the incubation of the disease after the infection has been received, we must obviously, in view of the foregoing facts, look for the arrival of the principal infection in the last two weeks of October, although it is evident that the epidemic had begun long before this time.

Below the diagram of weekly morbidity and mortality I have placed rectangles, cross-hatched, to represent, on the scale of dates which forms the basis of the diagram, the "periods of infection" of Stony Brook, by Cases No. I.–IV. Case No. I. may or may not have infected the brook during the two weeks previous to August 23; Case No. II., during the fortnight ending September 6; Case No. III., during the period September 23–October 9; Case No. IV. certainly contaminated and with almost absolute certainty infected the brook during the fortnight October 13–27. It will of course be understood that these periods, being based upon the two weeks previous to leaving work, do not exactly, although they probably do quite closely, correspond with the prodromal periods in each case.

A comparison of these periods with the wave of typhoid fever



Periods of Infection of Stony Brook.

cases which passed over Lowell is interesting and significant. The positive phase of the Lowell wave extends from September 15 to December 1, with only slight recessions, and covers eleven weeks. The positive phase of the infection wave of Stony Brook began on August 9 and extended, with interruptions, to October 27, covering almost the same period, viz., a little more than ten weeks. The epidemic in North Chelmsford began mildly but culminated with the last case that infected the brook, in a case of great severity, which ended fatally. It is certainly significant that in the third week following this particular pollution of the brook the most important outbreak of cases which had yet occurred took place. It is true that for a month after this week (November 10–17) there was every two weeks an increase of cases, so that the greater number of cases in any one week was between December 8–15; but an examination of the diagram will show that such increase was an exacerbation following a decline; and I believe that these two periods of exacerbation are due wholly to secondary infection, and not to any fresh infection. Upon this theory the curve should have precisely the form which it does have. The severest blow of the original infection struck down its victims November 10–17, after which the decline began, and, had it not been reinforced by secondary infection, it would have been more rapid. As it was, the decline was well established by December 15, and on the 29th had reached a point as low as existed on October 13. It is a striking commentary upon the difficulties in the epidemiology of typhoid fever that the epidemic was not reported until after December 20.

The Canal-water Theory.

On account of the canal-water theory urged as the true explanation of the epidemic, it became necessary to determine how many of the cases of typhoid fever might be attributed to the use of canal water. It was found, naturally, that, while many admitted that they had drunk canal water, most of those affected with typhoid fever who had worked in the mills could not say positively whether they had, or had not, done so. I find, however, that it suffices to settle the matter to assume broadly that all cases among mill people were attributable to the use of canal water. For, even if we do this, we still have left, among those who had no possible access to canal water, a majority of the whole number of cases, and enough

to constitute, by themselves alone, a serious epidemic. These facts are especially well shown upon the maps (Plates No. 2, No. 3). Only 230 cases were found which could possibly be in any case attributable to the use of canal water, while the majority, namely, 320, could not possibly have been due to this cause. The canal-water theory is therefore completely disproved; for, omitting the mill cases altogether, we still have a notable epidemic to deal with. Again, it must not be forgotten that most of the mill people when at home have access to city water exclusively, and that in one of the largest mills, the Merrimack, city water is as accessible as canal water. Besides, it is obviously altogether too liberal to assume, as we have done for the moment, that the mill cases were possibly all due to canal water. Some may have come from milk, or from polluted wells, or from city water.

It is now plain that, if the epidemic proceeded from drinking water at all, it must have come from the city water; but in passing we may remark that, although the figures prove that the epidemic was not chiefly due to canal water, it does, nevertheless, appear to be true that in the epidemic the mill people suffered most severely. We might, perhaps, expect that the mortality should be heavier among the mill people than in the city at large; and this appears to be true, inasmuch as 47 of the deaths from Sept. 1, 1890, to Feb. 1, 1891, out of a total of 92, or 51 per cent. of the whole number, are of mill people. We might perhaps expect a slight excess in the number of deaths among mill operatives, owing to their mode of life. But we should certainly not expect that 51 per cent. of the deaths and 42 per cent. of the cases would be among mill people, unless they were somehow peculiarly exposed to infection. It seems probable that these significant phenomena are the result of the use of some canal water for drinking purposes. The above figures become still more instructive if we remember that a considerable portion of the population, namely, the very young, is but slightly susceptible to typhoid fever. If we reckon the susceptible population of Lowell in round numbers at 70,000, we find that the cases for the epidemic period are 7.86 per thousand. Estimating the operatives of Lowell who had access to canal water at 23,000, which is probably too many, we find the actual morbidity during the epidemic period to be 230, or 1 per cent. The number required by the average for the whole susceptible population is, however, only $23 \times 7.86 = 181$. It

is therefore safe to say that the cases among mill operatives are in excess by at least 25 per cent. Moreover, inasmuch as we know that many mill operatives never drank canal water, we must conclude that those who did so suffered, as in fact they should have suffered, to an extraordinary degree.

The results of inquiry as to the kind of drinking water actually used, or believed by themselves to have been used, by those affected by typhoid fever are as follows: —

Total number of cases investigated,	550	
A. Cases that possibly had access to canal water,	230	
(*a*) Those who drank canal water only,		1
(*b*) " " " canal water in part,		65
(*c*) " " " city water only,		26
(*d*) " " " city water and well water only,		26
(*e*) " " " city and other water, but no canal,		19
(*f*) " " " well water only,		0
(*g*) " " " spring water only,		0
(*h*) " " " water, origin unknown,		93
B. Cases that did not have access to canal water,	320	
(*a*) Those who drank city water only,		252
(*b*) " " " city water and well water,		65
(*c*) " " " spring water and well water,		1
(*d*) " " " spring water only,		1
(*c*) " " " city water boiled five minutes,		1

Investigation of the Milk Supply of Lowell.

In order to include all possible causes of the epidemic, my assistant, Mr. McLauthlin, made a thorough study of the milk supplies of most of the cases investigated. Among 480 cases in which the milk supply could be traced, it was found that 135 milkmen (or milk companies) were involved. This fact alone makes the theory of wholesale infection of the milk supply extremely improbable, since these supplies came from many different farms and in most cases had nothing in common: —

Cases of Typhoid Fever in Relation to Their Milk Supply.

1 milk route had	20 cases,	20
1 " " "	14 "	14
2 " routes "	12 "	24
2 " " "	11 "	22
5 " " "	10 "	50
1 " route "	9 "	9
7 " routes "	8 "	56
6 " " "	7 "	42
5 " " "	6 "	30
7 " " "	5 "	35
11 " " "	4 "	44
10 " " "	3 "	30
25 " " "	2 "	50
40 " " "	1 case,	40
Cases using milk from private cows, 11		11
Cases who were served from stores, 50		50
		527
Deduct those counted twice,		47
Whole number of cases investigated,		480

Comparison of the number of cases upon each milk route involved, with the number of people served, showed that the number of cases was nearly proportional to the number of people served, the larger routes naturally having the most cases. This is never true of epidemics caused by infected milk. In order to make the evidence more conclusive, visits were paid to many of the sources of supply, but no evidence of possible typhoid infection was obtained at any of them. It was found, however, that many milkmen use city water with which to wash their cans.

It is possible that some cases of typhoid fever during this epidemic arose from the milk supply; but I find no evidence whatever that leads me to attribute any considerable part in the epidemic to infected milk.

Results of the Investigation.

Finally, in view of the facts already rehearsed, namely, that typhoid fever had long been excessive in Lowell, apparently solely on account of its polluted water supply; that the epidemic in ques-

tion was endemic in Lowell and not pandemic in the Merrimack valley; that it was very widely distributed over the city, and not limited to any particular district, and therefore was evidently due to some cause of a very general character; that a most remarkable and unusual near infection of the water supply (the Merrimack River) was found to have occurred at such a time and in such a place as to account perfectly for the wave of typhoid fever which passed over the city; that this wave of fever subsided after this particular infection ceased, and in view of the entire absence of any other plausible explanation, I reported to the water board of Lowell on April 10, 1891, my conviction that there was "danger both constant and grave" in the use of the unpurified water of the Merrimack River for drinking purposes, and my belief that the epidemic from which the city had suffered was due to the public water supply, infected by a special pollution of Stony Brook, in North Chelmsford.

This conclusion has now been generally accepted as correct. The city of Lowell has since undertaken to secure a supply of pure water, and has already appropriated for the purpose the sum of $100,000.

Two objections to my conclusions worthy of consideration have come to my notice. The first was, that if the fever had really come with the public drinking water it should have appeared wherever the water went, the number of cases in any district being directly proportional to the density of the population, while, on my own showing, remote districts, such as Middlesex Village, a sparsely settled district lying between Lowell and North Chelmsford (see Plate No. I.), and, in particular, the City Farm, the home of many of the paupers of the city, shown near the "Framingham and Lowell" railway on Plate No. I., had been entirely exempt during the epidemic. I was not unmindful of these facts, and the explanation of them is really extremely simple. It is well known that bacteria, as a rule, gradually diminish in numbers in the service pipes of a water supply. I had pointed out this fact in my report, and illustrated it as follows (p. 28): —

In the first place, the numbers of bacteria were very high, averaging in one set of samples 2,866 per cubic centimeter of water. This set of examinations was especially instructive, and, as it is in certain respects representative, it may be quoted in full.

Results of a Bacteriological Examination of the Merrimack River and the Lowell City Water.

1890.		Nos. of Bacteria per Cubic Centimeter.
Dec. 24. —	Merrimack River, over intake,	7,020
	Upper manhole, filter-gallery,	3,720
	Mixed water, gate house, Pawtucketville,	4,320
	Low-service reservoir, inlet,	3,780
	Low-service reservoir, outlet,	3,780
Dec. 23. —	Ward 1. A,	1,008
	Ward 2. B,	3,180
	Ward 3. C,	960
	Ward 4. D,	1,260
	Ward 5. E,	1,440
	Ward 6. F,	960

NOTE. — A cubic centimeter equals very nearly a cubic one-third inch, or, roughly, a thimbleful. It is usual for the numbers of bacteria to be somewhat smaller in the service than in the reservoir. They often appear to perish in the pipes. The ward samples were taken from taps in private houses.

These numbers soon declined, and have usually been lower, except under special circumstances of rain, thaws, etc. For example, on January 12 six samples of tap water were taken from Wards I., III. and V., and the average result per cubic centimeter was 315. On the other hand, great fluctuations were noted, showing a remarkably close connection between the river and the city water. Thus on January 22 there was a heavy, warm rain, which carried off much of the snow that had fallen on January 17 and 18. The rain began in the early morning. On the afternoon of the same day (January 22) the numbers of bacteria from five taps — one each on Chestnut, Oak, Pleasant, Cady streets, and one on Fletcher Place — averaged 15,000 germs per cubic centimeter. A few days later the same taps yielded only 500 bacteria per cubic centimeter. This is important, as showing the sensitiveness of the service to changes in the river. Even more significant than the numbers of bacteria were the kinds observed. In the earlier examinations large numbers of germs belonging to the pseudo-typhoid group were present. Many of these were clearly *Bacillus coli communis*. Another important fact was that from this highly peculiar condition of the water there was a gradual return to a more normal condition.

In a general way we may say that the typhoid fever was more abundant near the distributing reservoirs; and at the time of my earlier examinations the water pumped in from the reservoir made only a very brief stay there, as was shown by inspection and by the

close resemblance in bacterial results at and near the inlet and outlet. It will appear beyond that, in this respect, Lawrence, happily, differed widely from Lowell; and that it is probably to this fact that Lawrence owed its escape from a still more devastating epidemic than it had. It was a fact that the water from the river sometimes remained so short a time in the distributing reservoir at Lowell that muddy water was drawn from the taps in Centralville not far from the reservoirs. The explanation of the immunity of Middlesex Village and the City Farm is probably simply the long distances at which they lie from the reservoirs in Centralville, and also the fact that they use but little water at best, thus making the time of transit of the water very long. If it were necessary, it might also be urged that both places have a comparatively unsusceptible population, on account of the average ages of the residents.

The second objection was raised in a lengthy letter to a Lowell newspaper by the late Dr. N. B. Edwards of North Chelmsford, to whose kindness I have already referred. Dr. Edwards was unable to believe that the dejecta of one or a few persons could possibly contain enough germs to have laid low several hundred people in Lowell, and he looked to secondary infection as the probable cause of the epidemic. He urged that the Merrimack is a large, swift river; that only a very small fraction of it was drawn out by the pumps and delivered to the citizens of Lowell; and he elaborately computed the dilution which the dejecta must have undergone, coming to the conclusion that, closely examined, my theory involved a physical impossibility and consequent *reductio ad absurdum*.

In reply to this objection I can only say that while we do not yet know the numbers of typhoid-fever germs which one human intestine may throw off, we do know that of other germs it may discharge almost incalculable numbers in a single dejection.

The fact that probably only about 1,000 persons in Lowell out of 78,000 suffered from the disease during the whole epidemic (the latter part of which I, also, believe to have been caused by secondary infection), while 77,000 escaped, certainly suggests a very dilute infectious material. But in the famous Red Hill and Caterham (Eng.) epidemic a few discharges from one person were apparently sufficient to produce an epidemic of 351 cases and 21 deaths from typhoid in a population less than one-fifth as large as that of Lowell; and from the bacteriological point of view there is in such cases in reality no

difficulty. In view of the obvious facts of the present case already rehearsed, and of many similar cases which have been observed and studied by epidemiologists during the past forty years, as well as the important facts of other epidemics to the examination of which we must now turn, objections and speculations necessarily based upon data of which we are ignorant can have no weight.

The Epidemic of Typhoid Fever in Lawrence in 1890–91.

Soon after attention had been drawn to the epidemic of typhoid fever in Lowell described in the previous pages, it became evident that the city of Lawrence, nine miles below, was also affected; and on the same day that the citizens of Lowell were officially warned by the State Board of Health in a letter addressed to their mayor, the Hon. Geo. W. Fifield, a similar letter was sent to the mayor of Lawrence. The letter to the latter, together with an account of the principal facts of the Lawrence epidemic, has already been published by Mr. Mills, and may be found in the Twenty-second Annual Report of the State Board of Health of Massachusetts, pp. 528–541. Particularly noteworthy are the instructive facts developed in Mr. Mills's important supplementary letter to the mayor of Lawrence, dated Jan. 30, 1891 (*loc. cit.*, pp. 530–535), and especially the altogether unique and striking demonstration of cause and effect between the Lowell and Lawrence epidemics exhibited in the tables and the diagrams (pp. 538 and 539). So far as I am aware no more notable demonstration has ever been made in the whole history of epidemiology than is here displayed. The similar case shortly to be described, of an epidemic of typhoid fever on the Merrimack, involving three cities, namely, Lowell, Lawrence and Newburyport in 1892–93 forms an important addition to our series of investigations.

It is not necessary to repeat here the facts already so forcibly presented in the Twenty-second Annual Report. I may only add that the actual existence and the location of the individual cases in Lawrence were carefully determined for that city (chiefly by Mr. F. L. Fales and Mr. George V. McLauthlin) by the same methods used in Lowell (see p. 669) and that they were similarly studied and plotted. It was found that in Lawrence, precisely as occurred earlier in Lowell, the cases were not confined to any one section of the city, or to any particular class of the inhabitants. Nearly all, if not quite all, of the earlier cases attacked, as might have been

expected, were habitual drinkers of the city water; and there was in Lawrence a still more obvious prevalence of cases in those parts of the city which received water most quickly from the reservoir. In Lawrence, also, the milk supply as the cause of the epidemic was exonerated (Twenty-second Annual Report of the State Board of Health, p. 537), and any canal-water theory was shown to be untenable. Similarly, well-water and spring-water theories were excluded, and by the same kind of investigation employed in Lowell the epidemic was traced to the public water supply drawn from the Merrimack River.

Some of the phenomena of the Lawrence epidemic, however, may profitably be dwelt upon. One of these was its comparatively mild character, when we consider the extent of the infection of the river above. It was indeed urged upon me in Lowell as a serious objection to my theory of the Stony Brook cases as the cause of the Lowell epidemic, and indirectly of that in Lawrence, that if this theory were true: if four cases on Stony Brook had caused hundreds in Lowell: these same hundreds in Lowell must necessarily have caused thousands in Lawrence; while in fact actually fewer persons perished in Lawrence than in Lowell, although nearly as many, and in two months more, in proportion to the population.

But this objection is met, and the original theory is strengthened, by the following considerations. The objection supposes virtually similar conditions of water supply in the two cities; but such close similarity does not in fact exist. It is true that both cities use the Merrimack River as their source of supply; both also pump to distributing reservoirs and then distribute by gravity. But here the similarity ceases; and in other respects highly important differences exist. Stony Brook is three miles above Lowell, while Lowell is three times as far, or nine miles, above Lawrence. Lowell, during and before the epidemic period, pumped into a relatively small reservoir (of 30,000,000 gallons capacity), while Lawrence employed a relatively much larger reservoir (of 40,000 000 gallons capacity). Moreover, during the epidemic period, owing to the special arrangement of the inflowing and outflowing streams, the water scarcely more than passed into, and immediately out of, the Lowell reservoir; while at the same time the water in the Lawrence reservoir remained, nearly at rest, for about a week. Finally, owing to the relatively concentrated form of the city of Lowell and the situation

of its (low-service) distributing reservoir, its distribution of water to the majority of the people was largely radial, and therefore comparatively prompt; while, owing to the elongated form of the city of Lawrence and the situation of the Lawrence reservoir at one extreme end of the city, the journey of the water in the pipes was necessarily long. In a word, the conditions in Lowell were most unfortunately favorable for a quick delivery of infectious material by the water supply to the citizens, while those in Lawrence were, fortunately, comparatively unfavorable for similar quick delivery. It is obvious that, in spite of an excessive infection of the river which was the source of the water supply of Lawrence, compensating conditions existed which enfeebled the blow; and inasmuch as it has been learned at the Lawrence Experiment Station of the Board that time alone is needed to cause the germs of typhoid fever to perish in the water of the Merrimack River, we are justified in concluding that the conditions just described acted as a safeguard against an epidemic far more destructive than that which actually occurred.

But in spite of these conditions, an epidemic of nearly as great severity as that in Lowell occurred in Lawrence; and inasmuch as there is good reason to believe that this unusual epidemic was caused by the unusual infection of the river at North Chelmsford and at Lowell, it is interesting to observe that some of the infectious material was apparently able to survive the comparatively unfavorable conditions imposed by the long and slow passage through the Lawrence reservoir and the service pipes. It would seem, therefore, that, while much of it must have perished *en route*, some of it did not; and, as the time of year was November and December, we are safe in concluding that during these months under certain conditions some of the infectious material of typhoid fever may be conveyed nine miles by a river, may slowly travel through a distributing reservoir, and still remain effective to a very dangerous extent if swallowed in drinking water.

Typhoid Fever in the Cities of the Merrimack Valley, during the Five Years 1888–93.

Lowell and Lawrence, as has been shown above, are not the only cities of the Merrimack valley, but they are the only cities in which typhoid fever is usually excessive; and so far as I know they are

the only cities, not only in this valley but in New England, which suffered from a severe epidemic of typhoid fever in 1890–91. They are also the only cities in the Merrimack valley which draw their drinking water from a sewage-polluted river. By their own motion they were allowed to continue to do this when the statute was enacted prohibiting any city or town of Massachusetts from using for its source of water supply a stream into which sewage was poured at any point nearer than twenty miles above.

Upon the tables which immediately follow are exhibited, by months, the specific death rates from typhoid fever of Concord, Manchester, Nashua, Lowell, Lawrence, Haverhill and Newburyport (for the location of these cities see map at the beginning of this article) for the last five years, a period which has been taken in order to include the epidemic years of Lowell and Lawrence (1890–91), and those immediately preceding and following. But, instead of comparing the twelve months from January 1 to December 31 in each case, I have taken the period from April 1 to March 31 of the following year; for the reason that the autumnal wave of typhoid fever is not always spent by January 1, and in Lawrence the epidemic which gave rise to the present series of papers did not even reach its greatest height until after this time. The average wave of mortality from typhoid fever for Massachusetts as a whole reaches its highest point during the first week of October, and falls to its lowest point in June. (See diagram, by Dr. S. W. Abbott, Twenty-third Annual Report for 1891, p. 728.)

Typhoid Fever in the Principal Cities on the Merrimack River.

Deaths per 100,000 Inhabitants (Population from United States Census of 1890).

1888-89.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Totals (Death Rate from Typhoid Fever for the Twelve Months).
Concord, N. H., .	0	0	0	0	5.9	17.6	17.6	17.6	11.8	0	0	0	70.5
Manchester, N. H., .	0	2.3	4.6	0	0	4.6	0	6.9	6.9	2.3	0	2.3	29.9
Nashua, N. H., . .	5.3	0	0	0	0	15.9	31.8	5.3	10.6	0	0	0	68.9
Lowell, Mass., . .	10.4	7.8	3.9	3.9	3.9	10.4	6.5	9.2	9.2	5.3	6.6	9.2	86.3
Lawrence, Mass., .	11.2	9.0	11.2	2.2	9.0	0	17.9	13.4	13.4	4.4	15.6	17.9	125.2
Haverhill, Mass., .	0	0	3.8	0	3.8	3.8	3.8	0	0	3.8	3.8	0	22.8
Newburyport, Mass.,	0	0	0	0	0	0	0	0	7.2	0	7.2	0	14.4

1889-90.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Totals (Death Rate from Typhoid Fever for the Twelve Months).
Concord, N. H., .	5.9	5.9	0	5.9	0	0	11.8	0	0	0	0	0	29.5
Manchester, N. H., .	2.3	0	2.3	2.3	7.0	4.7	4.7	9.3	4.7	4.5	0	0	41.8
Nashua, N. H., . .	0	0	0	0	0	0	5.3	10.7	5.3	5.3	10.6	5.3	42.5
Lowell, Mass., . .	9.2	6.6	4.0	1.3	6.6	9.2	4.0	11.9	11.9	6.4	7.7	5.1	83.9
Lawrence, Mass., .	8.9	8.9	11.2	4.4	6.7	15.6	8.9	6.7	13.4	15.6	13.4	4.4	118.1
Haverhill, Mass., .	3.8	0	0	3.8	3.8	0	7.5	0	3.8	3.8	3.8	0	30.3
Newburyport, Mass.,	0	7.2	0	14.4	0	0	0	0	0	7.2	0	0	28.8

1890-91.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Totals (Death Rate from Typhoid Fever for the Twelve Months).
Concord, N. H., .	5.9	11.8	0	0	11.8	17.6	0	0	0	0	0	5.9	53.0
Manchester, N. H., .	0	2.3	0	2.3	4.6	6.9	0	6.9	11.4	4.6	4.6	0	43.6
Nashua, N. H., . .	0	0	0	0	0	0	0	0	0	0	5.3	0	5.3
Lowell, Mass., . .	7.8	10.4	11.6	7.8	7.8	12.9	12.9	36.3	32.3	24.6	18.1	12.9	195.4
Lawrence, Mass., .	11.2	0	11.2	2.2	2.2	4.5	11.2	15.6	42.6	47.0	26.9	13.4	187.0
Haverhill, Mass., .	7.5	3.8	0	7.5	0	11.3	0	3.8	0	0	0	0	33.9
Newburyport, Mass.,	0	0	7.2	0	0	14.4	21.6	0	7.2	7.2	0	0	57.6

TYPHOID FEVER IN THE PRINCIPAL CITIES ON THE MERRIMACK RIVER — *Concluded.*

Deaths per 100,000 Inhabitants (Population from United States Census of 1890) — Concluded.

1891-92.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Totals (Death Rate from Typhoid Fever for the Twelve Months).
Concord, N. H., .	5.9	0	0	0	17.6	0	5.9	0	0	0	0	0	29.4
Manchester, N. H., .	2.3	0	2.3	0	0	0	0	0	0	4.6	0	2.3	11.5
Nashua, N. H., . .	0	0	0	0	15.8	15.8	10.6	31.7	5.3	5.3	5.3	0	89.8
Lowell, Mass., . .	7.8	5.2	1.3	5.2	3.9	3.9	9.1	3.9	2.6	16.8	10.4	11.6	81.7
Lawrence, Mass., .	6.7	4.5	2.2	2.2	2.2	11.2	6.7	9.0	2.2	11.2	15.6	17.9	91.6
Haverhill, Mass., .	7.5	0	0	0	3.8	0	0	3.8	3.8	7.5	3.8	0	30.2
Newburyport, Mass.,	0	7.2	7.2	0	0	0	7.2	0	7.2	0	0	0	28.8

1892-93.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Totals (Death Rate from Typhoid Fever for the Twelve Months).
Concord, N. H., .	0	5.9	0	0	0	0	0	0	5.9	0	0	0	11.8
Manchester, N. H., .	2.3	0	4.6	6.9	0	2.3	0	0	2.3	2.3	0	0	20.7
Nashua, N. H., . .	0	0	0	0	0	5.3	0	15.9	5.3	0	5.3	0	31.8
Lowell, Mass., . .	5.2	9.1	2.6	5.2	5.2	9.1	5.2	3.9	12.9	12.9	9.1	5.2	85.6
Lawrence, Mass., .	6.7	2.2	4.5	9.0	4.5	0	6.7	9.0	20.1	6.7	26.8	17.9	114.1
Haverhill, Mass., .	3.8	0	3.8	3.8	0	7.5	0	3.8	22.5	0	15.0	3.8	64.0
Newburyport, Mass.,	0	14.4	0	0	0	0	0	0	7.2	21.6	0	7.2	50.4

These rates, though entirely comparable, are not absolutely exact, inasmuch as the population is taken in all cases as that which actually existed in 1890. The rates in 1888 and 1889 are therefore somewhat too low, and those in 1891–93 are probably somewhat too high, on this account. For the present comparison of these cities one with another, however, they are quite sufficient. The results are brought together for comparison by periods of twelve months in the following table : —

DEATH RATE FROM TYPHOID FEVER, BY PERIODS OF TWELVE MONTHS, IN THE PRINCIPAL CITIES ON THE MERRIMACK RIVER, FOR THE FIVE YEARS, APRIL 1, 1888, TO MARCH 31, 1893.

Deaths per 100,000 Inhabitants (Population from United States Census of 1890).

	From April, 1888, to March, 1889	From April, 1889, to March, 1890.	From April, 1890, to March, 1891.	From April, 1891, to March, 1892.	From April, 1892, to March, 1893.	Average, April, 1888, to March, 1893.
Concord, N. H., . . .	70.5	29.5	53.0	29.4	11.8	38.8
Manchester, N. H., . .	29.9	41.8	43.6	11.5	20.7	29.5
Nashua, N. H., . . .	68.9	42.5	5.3	89.8	31.8	47.7
Lowell, Mass., . . .	86.3	83.9	195.4	81.7	85.6	106.6*
Lawrence, Mass., . .	125.2	118.1	187.0	91.6	114.1	127.2*
Haverhill, Mass., . .	22.8	30.3	33.9	30.2	64.0	36.3
Newburyport, Mass., . .	14.4	28.8	57.6	28.8	50.4	36.0

* Excluding 1890–91 (the period of the great epidemic), the average for the other four years is 84.4 for Lowell, and for Lawrence, 112 25.

The final averages enable us also to draw a valuable comparison between populations under very similar climatic and social conditions, but one class having pure water supplies and another having polluted water supplies. The combined population of Concord, Manchester, Nashua, Haverhill and Newburyport was, in 1890, 121,800, while that of Lowell and Lawrence was 122,350. The average death rate from typhoid fever in the former group from April 1, 1888, to March 31, 1893, was 37.5 per 100,000; while that for Lowell and Lawrence for the same period was 116.9, or more than thrice as great.

These tables also reveal many other interesting facts. It is obvious that Lowell and Lawrence alone suffer from a constant excess of typhoid fever. The cities above and the cities below them upon the river do not on the average suffer half as severely as do either Lowell or Lawrence. It has been said that this was to be expected; that they are the largest cities in the valley, and contain a peculiarly susceptible population. But neither of these arguments is valid. Manchester, which has almost exactly the same population as Lawrence (see p. 667), falls very far below the latter in respect to its mortality from typhoid fever, having had only 29.5 deaths per 100,000 from this disease from April 1, 1888, to March 31, 1893; while during the same period the average for Lawrence was

127.2. That the prevalence of typhoid fever in a city is not necessarily connected with its size is still better shown by the fact that, while Lowell and Lawrence, the largest cities in the Merrimack valley, have suffered most from typhoid fever, Lawrence, with only about one-half the population of Lowell, has regularly suffered from this disease much more severely than Lowell has. (See the table of final averages, 1888–93, p. 698.) It is also a well-known fact that London and New York suffer very much less from typhoid fever than the smaller cities of Chicago, Philadelphia, Lowell, Lawrence, Albany, etc. As to the character of the population in Lowell and Lawrence, we are fortunately able to show that this also has here no special significance, and in no wise serves to account for the excess of typhoid fever in those cities over that in Manchester and Nashua; for Lawrence and Lowell are in respect to their principal industries and the character of their respective populations in no marked respect different from Nashua and Manchester; while Haverhill, Concord and Newburyport, although differing from Manchester and Nashua somewhat in this respect, resemble these cities closely so far as typhoid fever mortality is concerned.

In fine, we shall look in vain for any adequate explanation of the constant excess of typhoid fever in Lowell and still more in Lawrence except to the fact that both these cities have as constantly distributed to their citizens drinking water, unpurified, drawn from a stream originally pure but now grossly polluted with the crude sewage of several large cities and towns.

Turning to the tables once more, to see what light they throw upon the special epidemic of 1890–91, which gave rise to the present paper, we find that the severity of that extensive outbreak is strikingly apparent. Great as was the prevalence of typhoid fever in Lowell during the other (four) years (84.4 per 100,000), the wave of 1890–91 rose to more than double the usual height (195.4 per 100,000). Similarly in Lawrence, the average for the other years examined was 112.2, but for the epidemic year the rate is 187.0. If we inquire whether there had been in this year any unusual amount of typhoid fever in the cities above Lowell, we shall find from the table of final averages that, as far as these show, there was not. If we turn to the table of monthly rates (p. 696) for 1890–91, we shall find evidence that, while there had been some deaths in August and September in Concord and Manchester, there

had not been more than in some other years during these months; while during the epidemic period, namely, October, November and December, there had been very few. These facts oblige us to seek the cause of that epidemic in some unusual quarter; and, as I have already shown, there was, in fact, an extensive and near infection of the river, such as is not known to have occurred for forty years, through Stony Brook in the village of North Chelmsford, less than three miles above the intake of the Lowell water works. In the case of Lawrence, on the contrary, there was a remarkable increase in typhoid fever cases in one of the cities on the river above, namely, in Lowell. The infection of Stony Brook also occurred above Lawrence, so that we know that the water supply of Lawrence was unusually infected with the excreta of typhoid fever patients in 1890–91; and, however much we may deplore, we cannot be surprised at the result.

But there are still other lessons to be drawn from the tables. In spite of the severe blow which struck Lowell in 1890–91, and fell also heavily upon Lawrence, the towns and cities below Lawrence felt no shock of typhoid fever, while Nashua, their nearest neighbor above, was so free from it that only one typhoid fever death occurred in Nashua during the whole time that the disease was "raging" in the valley below. No more than this need be said to show how absurd are some of the ideas often advanced that "geographical position," "soil," "ground water," "climatic conditions," "telluric influences" and similar obscure or imagined causes affected Lowell and Lawrence unfavorably, and conferred exemption upon the neighboring cities and towns. As regards Nashua our tables plainly show that in 1891–92 there was a very serious and sharply defined epidemic of typhoid fever in that city, extending over seven months; but the citizens of Nashua do not seem to have recognized the fact, as I find no reference to it in the report of the municipal government of Nashua for 1891, or in that of the first annual report of the Board of Health of Nashua for 1892. This shows that moderate epidemics of typhoid fever may occur, run their course and terminate almost, or quite, without comment on the part of the authorities; and the same thing is illustrated by the fact that Nashua had another well-defined outbreak in 1889–90 (see tables), while Haverhill in 1892 had a very pronounced excess of typhoid fever, to which disease the only reference in the report of the local Board of Health

for that year is that "there were twelve deaths from typhoid fever, an increase of seven over last year." It would seem that an increase of typhoid fever to an amount more than double that of the previous year (see also Haverhill's record in table of final averages, p. 698) should deserve comment, if not investigation, at the hands of the sanitary authorities.

An Outbreak of Typhoid Fever in Lowell, Lawrence and Newburyport, in 1892–93.

By the courtesy of the Board of Health of Lowell, I have received every Monday morning for the last two years a statement of the number of cases reported and of deaths from typhoid fever (and other diseases) in that city during the previous week. My attention was thus suddenly directed, in December, 1892, to a marked increase in the number of cases of typhoid fever reported in Lowell. Soon afterwards I visited the city, and placed myself in close communication with the local Board of Health. The number of reported cases, however, soon began to decline, and the epidemic (if such we may call it) subsided. It was predicted that Lawrence would, as usual, probably suffer in its turn; and the mayor of Lawrence was duly warned. Before long in fact a wave of typhoid fever appeared in Lawrence, the cases multiplied, and deaths followed.

A little later it came to the knowledge of the State Board of Health that there was, or lately had been, a very unusual and unaccountable outbreak of typhoid fever in the city of Newburyport, lying below these cities, at the mouth of the Merrimack River. (See map at beginning of this article.) I was instructed to investigate the matter, and immediately proceeding to Newburyport, found that the rumor was well founded, and that a small but serious epidemic had passed like a wave over that city, very much as one had recently passed over Lowell, and, afterwards, Lawrence. I learned also that the Newburyport Water Company had been distributing to the citizens more or less of water drawn, unpurified, directly from the Merrimack River, contrary to recent and specific advice of the danger of so doing addressed to them by the State Board of Health and referring especially to the likelihood of an outbreak of typhoid fever if they should continue to do so. (See the official communication, dated Nov. 3, 1892, in the present volume, pp. 37 and 38.)

As I have said already, the cases in Lowell were most abundant in December; in Lawrence they were most abundant in January; and so also were they in Newburyport, as is shown by the following table: —

Reported Cases of Typhoid Fever.

	Lowell.	Lawrence.	Newburyport.
November, 1892,	19	14	0
December, 1892,	**70**	32	4
January, 1893,	38	**72**	**28**
February, 1893,	14	23	9

This table, taken in connection with the following, is instructive: —

Deaths from Typhoid Fever.

	Lowell.	Lawrence.	Newburyport.
November, 1892,	3	4	0
December, 1892,	10	9	1
January, 1893,	10	3	3
February, 1893,	7	12	0
March, 1893,	4	4	1

It would seem that the epidemic in Lowell produced both of those on the river below. There was a marked increase in the cases reported in Lawrence even in December, which suggests that Lawrence felt the same blow, to a small extent, that fell upon Lowell. The deaths in Lawrence also rose in December very much as they did in Lowell. But if we make this hypothesis, we may conclude that some water was at that time being drawn from the Merrimack River at Newburyport, and that the germs of the disease got to that point; for there were four cases reported and one death occurred there during December. I am inclined to believe that this hypothesis is well grounded; however that may be, it is very clear that the out-

break in Lowell was followed by a similar but more severe epidemic in Lawrence, and also one in Newburyport. The largest number of reported cases in Lowell was in December, and in Lawrence it was in January, as might have been expected. During the same month (January) twenty-eight cases were reported in Newburyport, for that city an unprecedented number. The following figures serve to enforce this point: —

Cases of Typhoid Fever reported in Newburyport.

December, 1891,	1	August, 1892,	1
January, 1892,	0	September, 1892,	1
February, 1892,	1	October, 1892,	4
March, 1892,	0	November, 1892,	0
April, 1892,	0	December, 1892,	4
May, 1892,	0	January, 1893,	28
June, 1892,	0	February, 1893,	9
July, 1892,	0	March, 1893,	3

By locating the cases and considering their relations to the public water supply, which enters at one end of the city, I found also that there were more cases in proportion to the water takers, or population, at that end of the city where the water is first and most quickly delivered. The cases were among all classes and very widely distributed.

It will be observed that the highest fatality in Newburyport was in January, while in Lawrence it was in February. This appears to be due to the interesting fact that the cases reported in the former were most numerous early in January but in the latter towards the end of that month. It would seem as if storage in the Lawrence reservoir had delayed the arrival of the infectious material in this case as in other epidemics in Lawrence. The February cases in Newburyport were grouped together in time and may have been caused by the January epidemic in Lawrence.

At the time of my visit to Newburyport I found the pumps in the pumping station which usually deliver good water from the wells of the company stopped for repairs. One pump was at work, apparently drawing water from the river. Later in the day I was informed by a prominent official of the company, that, owing to a scarcity of water, they had been obliged to draw more or less from the river since the previous summer (July, 1893). I was further informed that the proportion of river water had been on the average about two-sevenths of

the whole. I see no reason to doubt these statements, and it would appear from the vital statistics given that in spite of this fact the city escaped serious damage so long as typhoid fever was not abundant on the river above. But when the Lowell outbreak occurred, Newburyport as well as Lawrence suffered severely. It does not appear that Newburyport suffered any very great recurrence of the disease after the outbreak in Lawrence, although the February outbreak may have been due to this cause, and there were two more deaths in April. This may be owing to the fact that the water company had taken the alarm, and used but little of the river water, or that the citizens (who had become thoroughly aroused) had widely followed the advice of their local Board of Health, to boil all drinking water.

The occurrence of this epidemic in Newburyport and its apparent connection with the outbreaks in Lowell and Lawrence must be accounted one of the most interesting phenomena in our whole series of investigations, and may serve to confirm the truth of the saying that "no river is long enough to purify itself." It should not be overlooked that this outbreak appears to have been due to manifest neglect to follow the advice of the State Board of Health.

AN INVESTIGATION OF AN OUTBREAK OF TYPHOID FEVER IN CHICOPEE FALLS, APPARENTLY DUE TO INFECTED WATER SUPPLY.

By GEORGE VINCENT McLAUTHLIN, S.B., Late Instructor in Biology, Massachusetts Institute of Technology.

With a Prefatory Note by W. T. Sedgwick, Biologist of the Board.

(With Plate and Map.)

Note.

On April 27, 1892, the following communication was received by the State Board of Health from Dr. L. J. Gibbs, chairman of the Board of Health of the city of Chicopee: —

Chicopee Falls, April 26, 1892.

S. W. Abbott, M.D., *Secretary State Board of Health.*

Dear Sir: — Have there been any recent examinations of the water supply of this village? Quite a number of cases of typhoid fever have occurred within the past three months, four of them fatal, which leads me to suspect our water supply. No local cause can be found outside of this. Can you take any means to investigate the matter? Yours, etc.,

L. J. Gibbs, M.D.,
Chairman Board of Health of Chicopee.

On April 28 I received instructions from the secretary of the State Board of Health to make an investigation, and immediately sent my principal assistant, Mr. George V. McLauthlin, who was fortunately familiar with the local conditions, to confer with Dr. Gibbs. The result was the minute and painstaking inquiry a Report of which immediately follows. With so much of energy was the investigation conducted by Mr. McLauthlin that a conclusion was reached, a preliminary report was made to the State Board of Health, official action was taken by them, and one week

after the inquiry was ordered the following letter was sent to the Board of Health of Chicopee: —

Office of State Board of Health,
13 Beacon Street, Boston, May 5, 1892.

Dr. L. J. Gibbs, *Chairman of Board of Health, Chicopee, Mass.*

Dear Sir: — In compliance with your request, the State Board of Health has had an investigation made under the direction of Prof. W. T. Sedgwick, as to the cause of the increased prevalence of typhoid fever at Chicopee Falls, and finds reason to believe that it is due to the use of Chicopee River water for drinking purposes; and inasmuch as this stream receives the crude sewage of several thousand people, and is subject to frequent infection with the germs of disease, it is advised that the citizens using this water be warned to boil it before drinking, and that they take steps to secure a pure supply of water for domestic use.

Respectfully yours,
Sam'l W. Abbott, *Secretary.*

A special and melancholy interest attaches to the following paper by Mr. McLauthlin, as its author a few weeks later was accidentally drowned. He had served the Board with singular fidelity and success during the typhoid-fever epidemics on the Merrimack in 1890–91, as has been stated in my Reports above. He had also done exceptionally good work for the Board at Holyoke, Chicopee and Fall River, in the summer of 1891. At the time of his death he was preparing the present paper for publication, and had already submitted to me a draft of it. It is now printed substantially unchanged from his own manuscript, and constitutes, I believe, at once his first and his last published work. The thoroughness and insight which it manifests were characteristic of the author, in whose early death we have been deprived of a rare friend and a fellow-worker unusually gifted and unremittingly devoted to the advancement of knowledge.

William T. Sedgwick, *Biologist.*

On the 28th of April, 1892, Professor Sedgwick, biologist of the State Board of Health, informed me that there had recently been an unusual number of typhoid fever cases and deaths at Chicopee Falls, and instructed me to make an investigation. My first step was to examine the death records of 1891 and 1892, in order to obtain some idea of the limits of the unusual prevalence of typhoid fever which had been reported.

The following tables show the deaths from typhoid fever returned for those two years, up to May 1, 1892.*

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* The city of Chicopee contained in all, in 1890, 14,050 inhabitants. The location of "The Falls" and the "Centre" are shown upon the plate. (W. T. S.)

DEATHS FROM TYPHOID FEVER IN THE CITY OF CHICOPEE IN 1891.

In Falls Village (Population about 5,500).		*In Chicopee, exclusive of Falls Village (Population about 9,500).*	
May 7,	1	July 18,	1
July 20,	1	July 21,	1
Dec. 7,	1	Nov. 7,	1
		Dec. 2,	1
		Dec. 4,	1

DEATHS FROM TYPHOID FEVER IN THE CITY OF CHICOPEE IN 1892, UP TO MAY 1.

Jan. 13,	1	Jan. 25,	1
Jan. 24,	1	March 3,	1
March 14,	1	March 20,	1
April 13,	1		
April 23,	1		

Evidently there was no unusually large number of deaths from typhoid either at the Centre or at the Falls in 1891. My time was accordingly spent in inquiries concerning the early months of 1892, and an attempt was made to obtain reports of all the well-marked cases since Jan. 1, 1892. To this end all the physicians in Chicopee who could be found were interviewed. A few were away, but none having any considerable practice. Information was finally obtained of fifteen primary cases and four secondary cases at the Falls during that time, while only two or three primary cases were reported from the remainder of Chicopee. There were indeed several secondary cases in a poor French family at the Centre, but these were all obviously referable to a primary case in the same family which occurred in the previous November. In fact, two of the three deaths given above as occurring in Chicopee exclusive of the Falls in 1892, occurred in this family and were due in part, if not wholly, to neglect.

The mild epidemic at the Falls during the last four months had not been accompanied, therefore, by any unusual prevalence of the fever in the remainder of Chicopee. This of course excludes "climatic conditions," "effect of grippe," and the various indefinite causes of a similar nature, often assumed as the source of such epidemics, and points to some purely local cause.

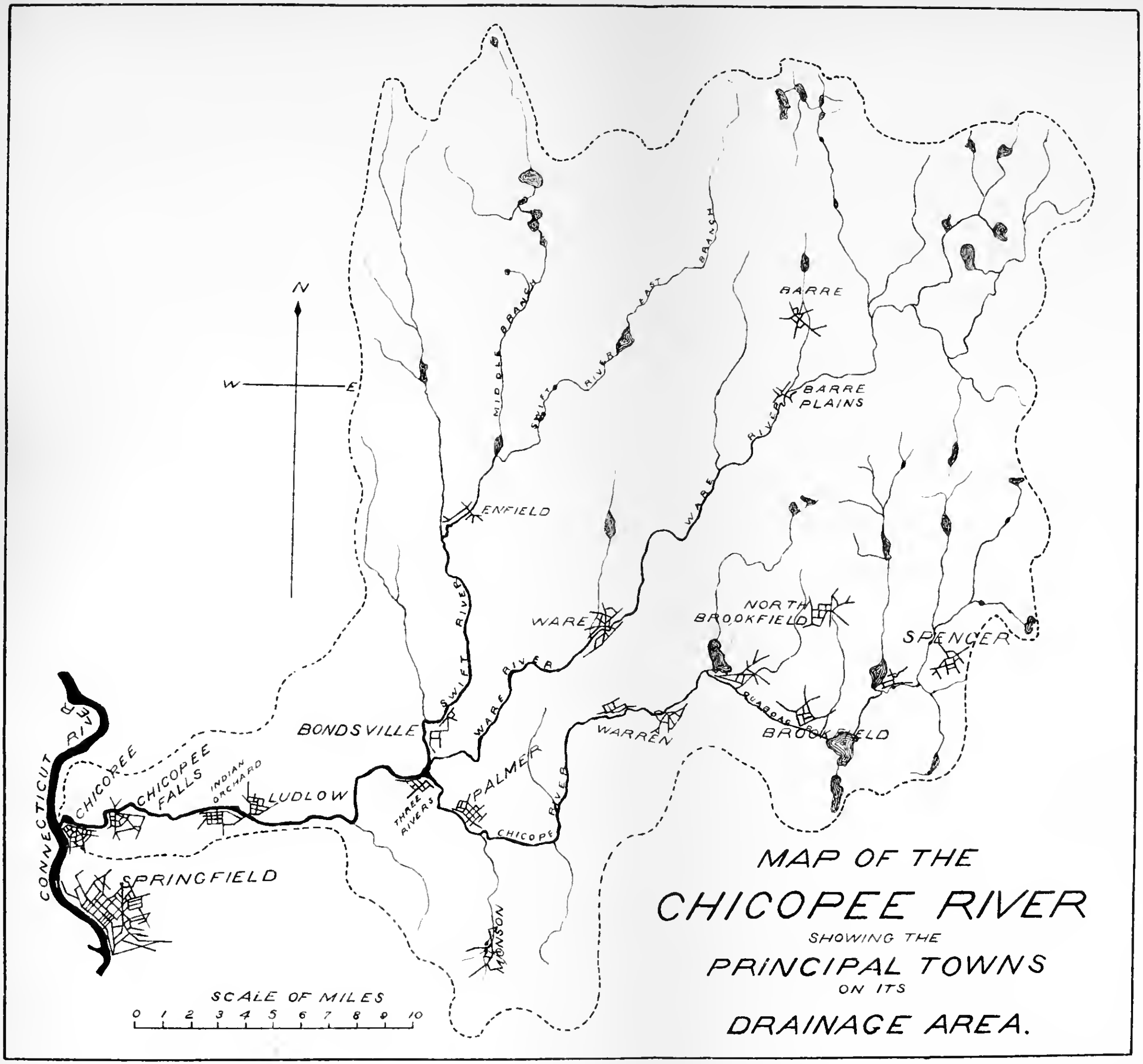
My inquiries did not end, however, with a mere determination of distribution, but included for each case the usual data with regard to residence, occupation, water supply, milk supply, etc.

A study of the results showed no evidence of infection by polluted well-water or contaminated milk. The evidence from the occupations of the patients and decedents was, however, more significant. Of the fifteen primary cases at the Falls since January 1, five were among non-operatives and ten among operatives. Of the operative cases two were employed in the cotton mills of the Chicopee Manufacturing Company (one thousand hands) and eight in the bicycle shops of the Overman Wheel Company (twelve hundred hands). In the other manufactories, which employed altogether between two hundred and three hundred hands, no cases are known to have occurred.

Of the five decedents, one was a Chicopee Manufacturing Company employee, two were Overman employees, one was a student at a business college in Springfield but lived at Chicopee Falls, and the fifth was a student in Easthampton who had been at his home at the Falls for a two-weeks vacation, and was taken ill with typhoid fever three or four days after his return to school.

There was nothing discoverable in the general condition of the shops of the Overman Wheel Company to account for the greater prevalence of typhoid fever among its employees than among those of the Chicopee Manufacturing Company. The location of the former is higher and dryer than that of the latter, and the sewerage system is quite as good. The employees of the Overman Wheel Company are of a better class than those in the cotton mills of the Chicopee Manufacturing Company. In short, no important difference was discovered between the two manufactories likely to influence the prevalence of typhoid fever among the employees except an important difference in the water supply.

The employees of the Chicopee Manufacturing Company are supplied with comparatively pure drinking water from springs on the Armory-Hill road. Although this water is exposed to occasional contamination by the excrement of cattle, there is no probability of any infection by typhoid-fever germs. This water is supplied for drinking in pails, while the public water supply in faucets is used for washing. Of course some of the latter is occasionally used for drinking, but the majority of the operatives probably drink the spring water. In the small manufactories referred to above an unpolluted water is also supplied for drinking.



N
W
E
BARRE
BARRE PLAINS
EAST BRANCH
SWIFT RIVER
MIDDLE BRANCH
ENFIELD
WARE RIVER
WARE
NORTH BROOKFIELD
SPENCER
SWIFT RIVER
BONDSVILLE
WARE RIVER
QUABOAG
BROOKFIELD
WARREN
CONNECTICUT RIVER
CHICOPEE
CHICOPEE FALLS
INDIAN ORCHARD
LUDLOW
THREE RIVERS
PALMER
CHICOPEE RIVER
SPRINGFIELD
MONSON
SCALE OF MILES
0 1 2 3 4 5 6 7 8 9 10
MAP OF THE
CHICOPEE RIVER
SHOWING THE
PRINCIPAL TOWNS
ON ITS
DRAINAGE AREA.

In the shops of the Overman Wheel Company, however, for a long period the public water supply alone has been used for drinking, and up to within a few weeks. This public water supply comes from the Chicopee River (see "Intake," upon a canal in Chicopee Falls shown upon the plate), and is subject in many places above to pollution with crude sewage. The idea had already been suggested that the polluted Chicopee River water was responsible for the difference in typhoid morbidity and mortality between the two manufactories. But the objection might have been raised that the Chicopee Manufacturing Company's employees have access to Chicopee River water at home, and so ought to show almost as many cases as the Overman employees. As a matter of fact, however, most of the Chicopee Manufacturing Company's employees live in the company's tenements in the oblong bounded by West Main, Blake, Grove and Main streets. There are also a few blocks across Grove Street between Court Street and Market Street. All these tenements may be located on the accompanying plate.

Examination of the polluted cases shows that in these tenements, inhabited though they are by a poor and often unclean class of people, there had been but one case of typhoid fever since Jan. 1, 1892, against eighteen in the remainder of the Falls. This fact is the more striking when it is added that these tenements are crowded with from fifteen hundred to eighteen hundred people, or about one-third or one-fourth of all the inhabitants of Chicopee Falls. The single case which occurred in these tenements, moreover, was that of a boy who had been working all day and often a part of the night at the Overman shops, which are provided with the river water. Again, the condition of these tenements, though fair, is not above the average of the Falls houses, nor are the tenants of superior intelligence. The only peculiar thing about these tenements, so far as I have been able to discover, after the most careful inquiries, is that they are all supplied with an uninfected spring water of the same kind which is used in the mills of the Chicopee Manufacturing Company. This water is freely supplied in faucets, and no river water is to be had in these houses. It is certainly most significant that among these people there had been but one case of typhoid fever since Jan. 1, 1892, and that the case of a boy who probably drank river water at the Overman shops where he worked.

As stated above, most of these tenements are occupied by employees of the Chicopee Manufacturing Company and their families.

The following is certainly a striking fact: there is a large tenement on Blake Street, belonging to this company, which, unlike the houses just referred to, is supplied with river water. In this tenement there was in January one death from typhoid fever, followed by two secondary cases.

All the evidence up to this point strongly confirmed a theory advanced in 1891 by me, in a special report to the Board, viz., that the Chicopee River water had been mainly responsible for the typhoid fever at the Falls. As was then pointed out, the Chicopee River receives considerable crude sewage at several points above the Falls.

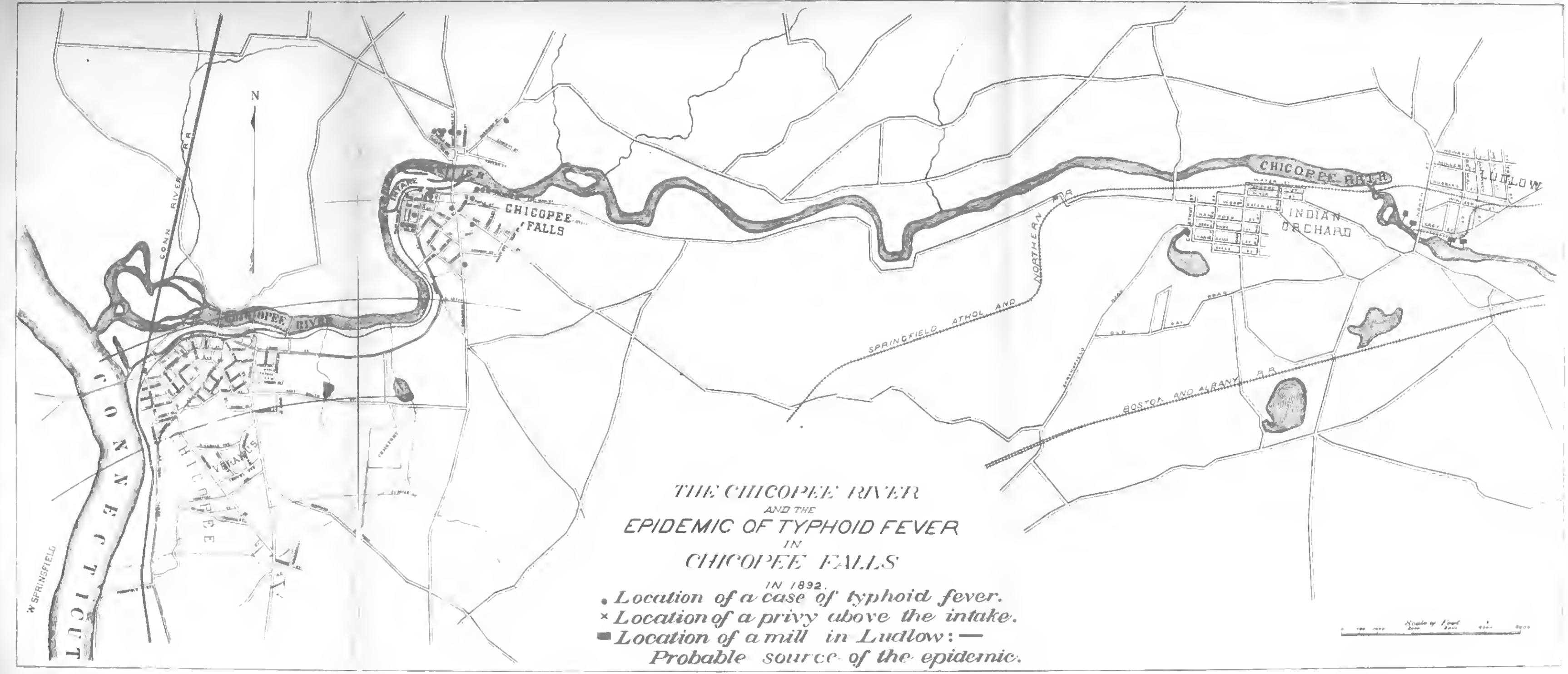
It still remained, however, to account for the fact that, although Chicopee Falls had been using this polluted water supply since 1883, and since then has had on the average a considerable annual excess of typhoid fever, its death rate from this disease being greater than the average for the cities of the State, yet it has not hitherto suffered as severely as it has this year.

Careful investigations were accordingly made in the most important towns and villages regularly polluting the Chicopee River, to ascertain if there had been any *unusual* infection by typhoid fever germs during the winter and spring of 1891–92. In every case the town clerk's records were examined, and many or all of the local physicians consulted.

(The drainage area of the Chicopee River is large, and upon it are several important towns. The accompanying map shows the course of the river and its tributaries, as well as the situation of the principal towns and villages upon its drainage area. — W. T. S.)

Monson was the first town visited. Here about five hundred people contributed raw sewage to a feeder of the Chicopee River. The physicians, however, informed me that there had been no cases of typhoid fever here since August or September, 1891, and that the few cases occurring in those months were so placed that they did not infect the river.

In the town of Palmer proper, according to Mr. Brainerd, the chairman of the selectmen, the sewage from fifty or seventy-five families, a few hotels and a small mill runs directly into the river. The only case of typhoid fever within a year, of which information could be obtained, was that of a woman who was taken ill some time in November, 1891, and on December 14 died of undoubted typhoid fever. Her house was connected with the sewer.


THE CHICOPEE RIVER
AND THE
EPIDEMIC OF TYPHOID FEVER
IN
CHICOPEE FALLS
IN 1892.
• Location of a case of typhoid fever.
× Location of a privy above the intake.
▬ Location of a mill in Ludlow: —
Probable source of the epidemic.
CHICOPEE RIVER
CHICOPEE FALLS
INDIAN ORCHARD
LUDLOW
CONNECTICUT
CONN RIVER R.R.
SPRINGFIELD ATHOL AND NORTHERN R.R.
BOSTON AND ALBANY R.R.
W. SPRINGFIELD
CHICOPEE
INTAKE
N

In the outlying villages of Palmer, i.e., Three Rivers, Bondsville and Thorndike, there are several mills, employing in all at least fifteen hundred to two thousand hands, the sewage of which runs directly into tributaries of the Chicopee. In none of these villages, however, were there any well-marked cases of typhoid fever during the fall and winter of 1891 or the spring of 1892.

In Ware, as I was informed by Mr. Eaton, superintendent of sewers, about one hundred and seventy-five families and two thousand mill employees contribute raw sewage to the Ware River. There was more typhoid than usual in Ware during the year ending March, 1892, as is pointed out in the Town report for that period. Twenty-five cases and five deaths were reported during that time, while but one death occurred in the preceding year. Most of these cases and deaths, however, occurred in the fall; viz., one death in September, 1891, one in October, two in November and one on Jan. 2, 1892. A part of the cases occurred among operatives, though the decedent of January 2 was a non-operative, and his house was not connected with the sewer. In brief, I was able to learn of but one case of typhoid fever in Ware since Jan. 1, 1892, and in that instance the patient was not a Ware operative, and his residence was not connected with the sewers. No probable connection could be traced, therefore, between any Ware cases and those in Chicopee Falls in February, March and April of this year.

The towns already referred to were the only ones upon the tributaries of the Chicopee River which it was considered necessary to visit. On the Chicopee River itself, above the Falls, the only villages pouring sewage into the river (except Three Rivers, which has already been considered) are Collins, Ludlow (including Jenksville) and Indian Orchard. At Collins the sewage from a few hundred mill hands goes directly into the river, but no well-marked cases occurred during the period under consideration. At Indian Orchard about one thousand people contribute raw sewage to the river. There were several cases of typhoid fever here in the autumn, and somewhat more than usual, but nothing could be learned of any cases since Jan. 1, 1892.

Up to this point the evidence seemed to show that during the previous autumn the infection of the Chicopee River by typhoid fever germs was perhaps somewhat greater than usual. But it still remained to account for the prevalence and severity of the outbreak during the first four months of 1892. The distribution of the cases

was such as to render secondary infection as a chief cause improbable, and it was impossible that the infection of the river by the fall and early winter typhoid cases in Indian Orchard, Palmer and Ware could have continued to be effective during the first three or four months of this year. If the river water were at fault, there must have been some unusual infection by typhoid excreta during the first few months of this year.

For some time nothing was learned of any such occurrence, but at length it was discovered that there had been such an unusual infection, and that it took place only a few miles up the river, at Ludlow and Jenksville which form practically one settlement, the name Jenksville being applied to that portion of it on the south or Springfield side of the river. Here about eight hundred mill hands and one hundred to one hundred and fifty other persons contribute raw sewage to the river. The population of the village is only about fifteen hundred, and deaths from typhoid fever have hitherto been rare. During the past year, however, there were three deaths; one in October, 1891, one in November, 1891, and one in February, 1892. I was unable to get an accurate census of the cases during the same period, but was assured by the physicians that there was an unusual number of cases. These began in the fall *and extended into March*, but all had recovered or died before my visit.

Most of them occurred in the company's tenements in Jenksville, and were attributed by one of the physicians and some of the tenants to bad sanitary conditions. Some of the privy vaults are open in the back and so near the blocks as to create a nuisance in warm weather. Moreover, the contents of the vaults are said to be washed out by heavy rains, and so brought dangerously near the wells, some of which are only forty or fifty feet away. These privies are not connected by drains or sewers with the river, and in fact, so far as I have been able to learn, none of those ill with typhoid fever between October, 1891, and March, 1892, lived in houses connected with the sewers. Many, probably most, of them however worked in the Ludlow Mills, and so could easily have infected the river during the prodromal period, since all the sewage from these mills runs directly into the Chicopee River. The journey of infectious material to the intake of the water works of Chicopee Falls, if the mills along the river were running as usual, would take but a short time. As the water supply at the Falls is pumped directly into the pipes during the day without going through

the reservoir, a very few hours might suffice for the transfer of typhoid bacilli from a human intestine in Ludlow to one in Chicopee Falls.

A single case will serve to illustrate the way in which the river was infected. A boy operative named Caissy, who lived in one of the company's tenements in Jenksville, was taken with severe diarrhœa during the last of January, 1892. During the course of one day he was sometimes obliged to visit the mill water-closet (which leads directly to the river) four or five times, yet he kept at work for a week or more. The first week in February, however, he was obliged to take to his bed. The illness was of long duration and, as I was informed by the attending physician, was undoubtedly typhoid fever. The symptoms were typical, and included delirium and rose-red spots. It was not necessary to inquire as minutely into the details of every case which occurred during the period under consideration. Enough was learned to show that several operatives having typhoid fever had infected the river in a similar way between October, 1891, and April, 1892. Moreover, this infection was decidedly more extensive than anything which could be discovered in previous years, and was, I believe, sufficient in time, intensity and duration to account for the mild epidemic in Chicopee Falls in the spring of 1892.

The pollution of the river took place about seven miles above Chicopee Falls. (See plate above.) No other near infection of the river by typhoid germs is known to have occurred during these months. There is, however, a possibility that such an infection may have taken place, and at a point much nearer the intake than anything yet mentioned. Until after my visit there were in Chicopee Falls itself, between one-half and three-fourths of a mile above the intake of the water works and on the same side of the river, several privies which either directly overhung the Chicopee River or had vaults of such shape that a hard rain might wash a part of the contents into the river. The position of these privies is approximately indicated upon the plate given above, on East Main Street, nearly opposite Linden Street. Until the recent epidemic, no cases of typhoid fever have occurred in these houses or any near by within five years at least. The plate shows, however, that one of these dangerous privies belonged to a house in which a case of typhoid fever occurred in 1892. There were also cases in the two houses next west, but in these the privies,

although near the river, were so built that the contents probably could not reach the river. Inquiries showed that such excreta as were not thrown into the privy were carefully buried behind it, within a hundred feet of the river to be sure, but yet in such a way that nothing would be likely to get into the river. I was assured and, so far as I could learn by the most careful inquiry, the method of throwing slops directly into the river or on the sloping river bank, which I happened to witness at a house near by, was not in vogue in these cases. As already pointed out, the other river-bank case occurred in a house provided with a dangerous privy. Its contents were completely exposed on the river side, and a hard rain might wash a portion down the bank into the river, which was less than a hundred feet away. The patient in this house was a little girl of eight years, who went to bed about March 17. The physician feels sure that the illness was typhoid fever, and says that she had considerable diarrhœa. All excreta were thrown without disinfection into this vaultless privy. So far as I was able to learn, no severe rains occurred between the beginning of her illness and the date of my visit to Chicopee Falls, and it is probable that no considerable infection of the river had taken place up to that time. I at once drew the attention of the local board of health to these matters, and urged the immediate removal of this and all similar privies. I am very glad to be able to report that a day or two after, i. e., during the first week in May, this privy was cleaned, and boarded up so as to prevent its contents from washing into the river, while the other dangerous privies, also above the intake of the water works, were removed. Up to May 30 no more cases of typhoid fever at the Falls had come to the knowledge of the local board of health. This fact, and the others cited above, make it probable that little or no harm has been done by these privies, in spite of their extremely threatening position directly upon the river, above the intake of the water works.

In fine, all the evidence which I have been able to discover indicates that the mild typhoid epidemic in Chicopee Falls during the past winter and spring was due to some unusual infection of the public water supply. This contamination of the water supply may possibly have been due in part to cases of typhoid fever in Indian Orchard or Ware, or to cases on the river bank above the intake in Chicopee Falls itself; but was probably for the most part the result of an unusual prevalence of typhoid fever during the previous winter and spring among mill operatives at Ludlow and Jenksville.

AN INVESTIGATION OF AN EPIDEMIC OF TYPHOID FEVER IN THE CITY OF SPRINGFIELD IN JULY AND AUGUST, 1892, DUE TO INFECTED MILK.

BY W. T. SEDGWICK, Ph.D., BIOLOGIST OF THE STATE BOARD OF HEALTH,

AND

WALTER H. CHAPIN, M.D , CITY PHYSICIAN AND MEMBER OF THE BOARD OF HEALTH OF SPRINGFIELD.

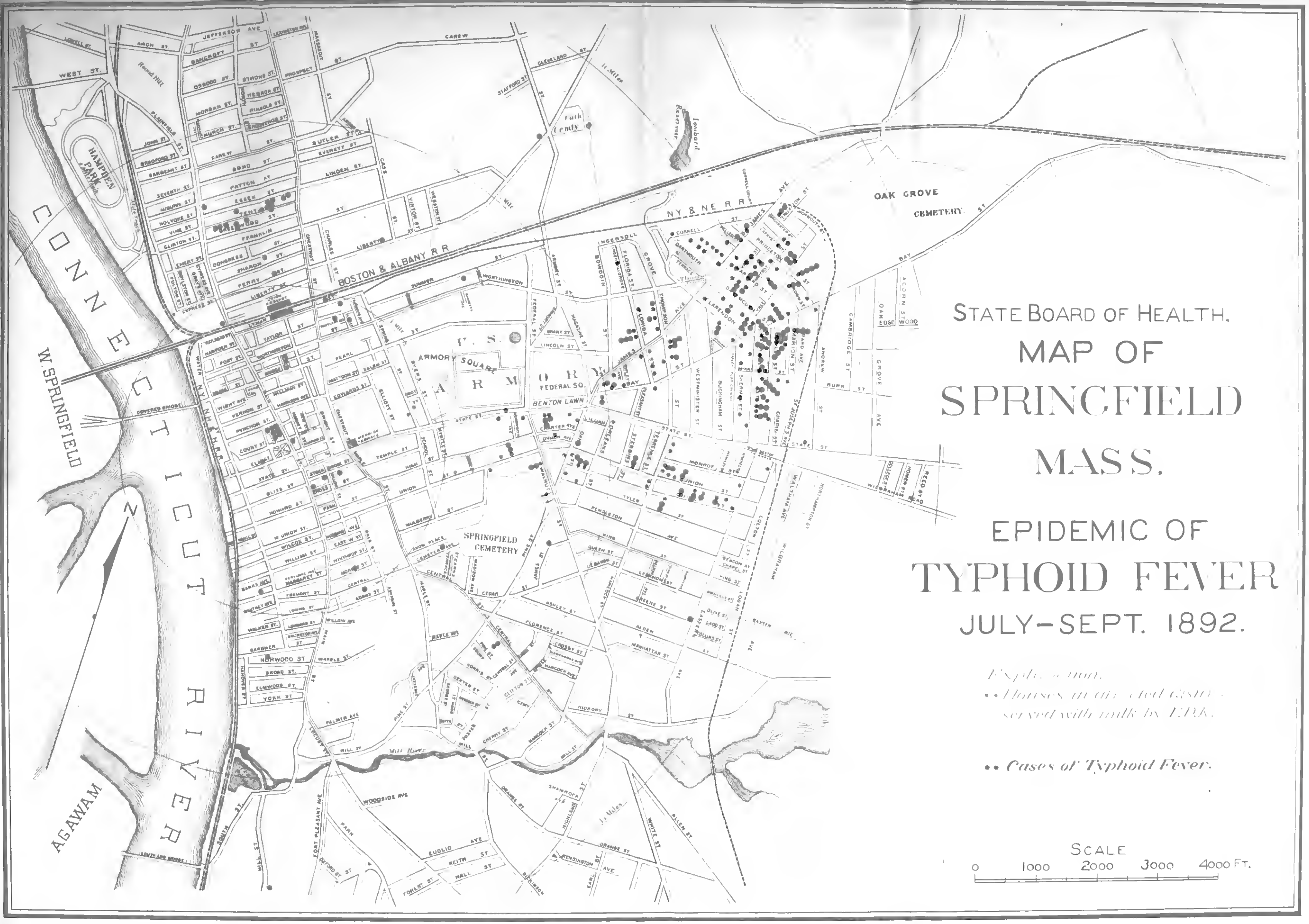
(With Map, Plates and Figures.)

About the first of August 1892, it was noticed that typhoid fever was unusually abundant in a particular district of the city of Springfield. This city (of about 47,000 inhabitants) covers a large area extending north and south along the Connecticut River and, upon somewhat higher land, to the eastward. Its soil is chiefly sandy or gravelly, and the situation is regarded as salubrious. The particular district in which typhoid fever began to appear in such abundance as to excite comment and at length alarm is known as the "McKnight district" and lies upon a gravelly plateau of wide extent, such as often characterizes the terraces of the Connecticut valley. It may be located upon the accompanying map as that portion included between State Street and St. James Avenue. The district has been comparatively recently "developed" by enterprising real-estate activity, and may fairly be described as having a refined and attractive suburban character; the houses, mostly of wood, standing somewhat back from the street, are provided with grassy yards or lawns and sometimes with gardens. The sanitary arrangements are in keeping with the exteriors; in brief, the district forms an inviting, wholesome and excellent suburban community. There are other parts of the city, similarly situated, some as good, some better, than this; but most of the city is far

less favorably situated, less inviting, less clean, and in parts, especially along the river, crowded with tenement-houses; still other portions consist chiefly of shops or stores or offices, amongst which dwellers of a lower grade are crowded. But in none of these except the McKnight district did typhoid fever make its appearance in July, 1892.

The perplexity of the people, therefore, was great, and, as is usual in such cases, various theories were advanced to account for the epidemic. Some of these were manifestly untenable; others, although resting only upon vague conjecture, were soberly propounded and seriously discussed among the citizens and in the newspapers. Even physicians and the local sanitary authorities were deeply perplexed. Attention was first drawn to well water as a possible cause of the disease, some of the people in the McKnight district having resorted largely to well water in preference to the city water during the hot months. But it was naturally urged as a sufficient objection to this hypothesis that many, indeed most, of the victims had used only the public water supply for drinking purposes. A similar hypothesis was advanced in respect to certain spring waters widely sold in the district, but the same objection was effectively raised in this case. Some turned to the drainage and some to the sewerage of the district as the probable source of the trouble. But it was immediately pointed out that the houses affected were mostly new and the plumbing was generally in good condition. With respect to the sewers, a stench from the man-holes in the neighborhood of Yale Street was said to be very noticeable at times, and we found that this was a fact; but the superintendent of sewers showed that this was an incident of the hot season; that the smell was no worse this year than in previous years when there had been no fevers; that the fall of the sewers was unusually good and the system of flushing them excellent. Moreover, many of the houses nearest to the man-holes had no typhoid fever cases; so that the sewer-gas theory, also, proved to be inadequate to account for the outbreak.

The officers of the local board of health began work upon the impure-water theory, and in conjunction with a local chemist proceeded to examine chemically the numerous wells of the district. They found several wells containing large amounts of chlorine, and many which gave evidence of more or less remote sewage contamination.


STATE BOARD OF HEALTH.
MAP OF
SPRINGFIELD
MASS.
EPIDEMIC OF
TYPHOID FEVER
JULY–SEPT. 1892.
•• Cases of Typhoid Fever.
SCALE
0 1000 2000 3000 4000 FT.
CONNECTICUT RIVER
W. SPRINGFIELD
AGAWAM
HAMPDEN PARK
BOSTON & ALBANY R R
NY & NE R R
OAK GROVE CEMETERY
SPRINGFIELD CEMETERY
U. S. ARMORY
ARMORY SQUARE
FEDERAL SQ.
Mill River

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But in spite of their results it remained an insuperable objection to the theory of water contamination as the cause of the trouble that some of the cases had had no access to well water.

Still new cases of fever continued to appear, and the local perplexity increased. It was observed by some of the citizens and made known that many of the families affected were served with milk by the same milkman. The city physician, therefore, communicated with the latter, and on August 8, by which time there were known to be twenty or more cases of fever in the district, visited under the guidance of the milkman himself the several farms from which he derived the milk furnished to his patrons in different portions of the city. All of the farms were thus visited by the city physician except one, which, he was informed, had already been visited by a well-known and competent physician of Springfield, and found to be in good condition. He was further informed by the milkman that all of the milk distributed to the McKnight district had come, invariably, from two farms in Agawam, a town adjoining Springfield, and these he found to be excellent farms in good condition with no history of any typhoid fever upon either of them. It was learned also that the milkman's cans were washed and steamed only at the Springfield Co-operative Milk Association's headquarters, and that there was no reason to suspect that the origin of the fever was in any way connected with the water thus used; for the same water, under the same system, at the same place, was used for many other dairymen's cans, and no typhoid fever had appeared upon their routes. The conclusion drawn from the results of investigation of the milk supply was therefore, as stated in a local newspaper on August 9, that the milk-infection theory was "entirely set aside."

In the mean time it had been suggested that the comparative proximity of a neighboring cemetery might be the hidden cause of the epidemic, and a cemetery theory was fully dicussed in all its bearings. It received a severe blow when it was found that a well in the cemetery itself contained less ammonia than the wells in the McKnight district, but it continued for some time to hold a place among the favorite theories, in spite of the fact that there was not a particle of evidence in its favor, and every reason to reject it. It was hard pressed by the sewer-gas theory, especially on those streets with odoriferous man-holes; but both soon after lost some adherents.

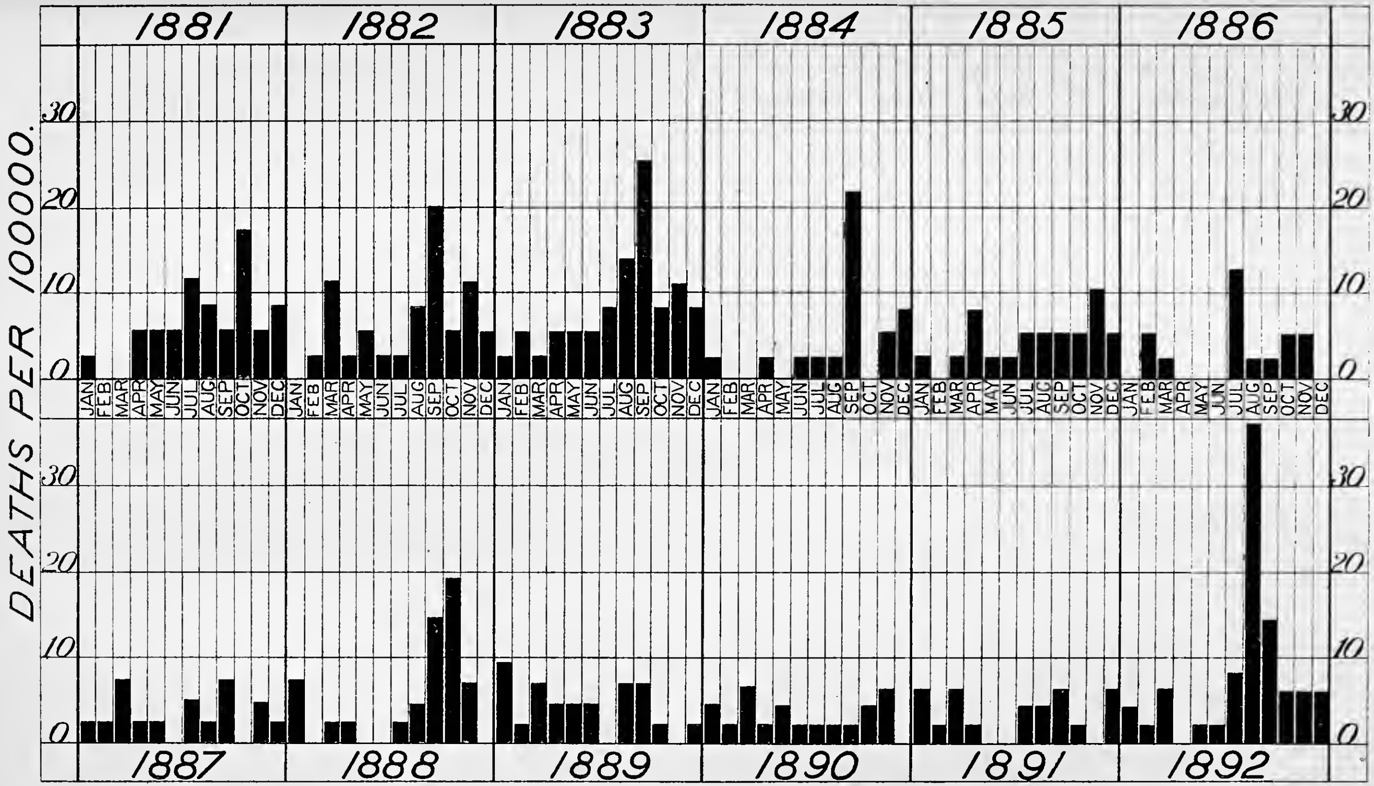
who went over to the infected-vegetable theory, namely, the theory that green foods, such as lettuce, tomatoes, celery, having been splashed by liquid manure previously infected, had been eaten uncooked, possibly in salads, and had thus produced the disease. This theory, however, like most of the theories advanced, failed to explain why the people in this district only were affected, or why, among all the families in this district, the particular families affected had been smitten. Last in the series the theory of ice infection was brought forward as the probable cause of the outbreak; but inasmuch as the ice supply of this district was in no respect different from that of the rest of the city, and the affected families had been served by the same carts as many families totally unaffected, this hypothesis also seemed to be untenable.

It is interesting to bring together, as more or less typical of the vague and often wholly unsupported speculations as to the cause of particular epidemics of typhoid fever, those which were propounded in the present case and were deemed worthy of mention in the public prints. They were as follows: (1) impure well water; (2) impure "city" water; (3) defective drainage or plumbing; (4) defective sewerage, or sewer-gas; (5) infected milk; (6) influence of a cemetery, probably upon the well-water supply; (7) infected vegetables; (8) impure ice. These were not all of the theories advanced, but they suffice to show the usual condition of public opinion in the presence of an outbreak of typhoid fever.

All of these theories, if such they may be called, were propounded and discussed at much length, both in private and in the public prints, within the first week after attention had been drawn to the epidemic. During the second week the local debate was actively continued, but no new theories were advanced, the State Board of Health was not notified, no serious investigation was made, and no just conclusion was reached. The anxiety and alarm of the citizens remained undiminished. Finally, in the third week of the debate, the State Board of Health was appealed to, and one of us (W. T. S.) was sent to the aid of the local Board of Health, arriving in Springfield on August 14.

On August 15 the authors began a joint investigation of the cases themselves, using for the purpose the blank already described in connection with the epidemic in Lowell (see p. 670). After nineteen houses in the infected district had been visited and forty-six

TYPHOID FEVER IN SPRINGFIELD.



MONTHLY MORTALITY 1881-1892.

cases examined, it became clear that all theories hitherto advanced were untenable except the milk theory. No other common bond of connection whatsoever could be found, but *all of these families except one had been taking milk from the same milkman*, as had already been alleged but not proved. This milkman (F. D. K.) was by no means the only milkman who sold milk in the McKnight district, but we soon discovered that he was the only one upon whose service there was any typhoid fever. In the exceptional case mentioned above we afterwards found that the family got milk regularly from another dealer (upon whose route there was no other case of typhoid fever), but that almost as regularly this family bought milk from a grocery supplied by F. D. K. We therefore concluded provisionally that the epidemic was probably due to infected milk; but inasmuch as it seemed to be plain that one of us (W. H. C.) had already been misled, we did not immediately announce our conclusions, although we straightway acted upon them and proceeded to interview and cross-examine more closely F. D. K., the milkman who had served the infected houses with milk.

By him we were informed that all of the milk which had been supplied to the infected houses had come from the two farms in Agawam already referred to above. Upon this point he was positive and explicit. On the next day, therefore, we visited Agawam, in the hope of finding the source of the infection. As has been said above, these farms had already been visited by one of us (W. H. C.) on August 8, in company with F. D. K. himself, and found to be in good condition; but to our surprise we now discovered on one of them, on the 16th, a well-marked case of typhoid fever, which had apparently developed since the visit on the 8th just referred to. The most careful cross-examination of the family (which was that of a well-to-do farmer) gave no indication of any previous case of typhoid fever on the farm, and this one seemed to have contracted the disease in Springfield, thus sharing, rather than explaining as a cause, the outbreak there. It was possible, however, that the local well which, as is usual in such cases, was not far from the privy, had somehow got infected, had conveyed the disease to the milk, through washing of the pails or otherwise, and had thus infected in turn not only those in the McKnight district served with the milk, but also the farmer's son, who might have got the disease either in this way or directly from drinking the water of the well: his parents, who

were beyond the most susceptible age, having escaped. Much perplexed, we therefore took samples from the farmer's well for chemical and bacteriological examination in the laboratories of the State Board of Health in Boston. Bacteriologically the water proved to be unobjectionable, and chemically showed an excellent purification.

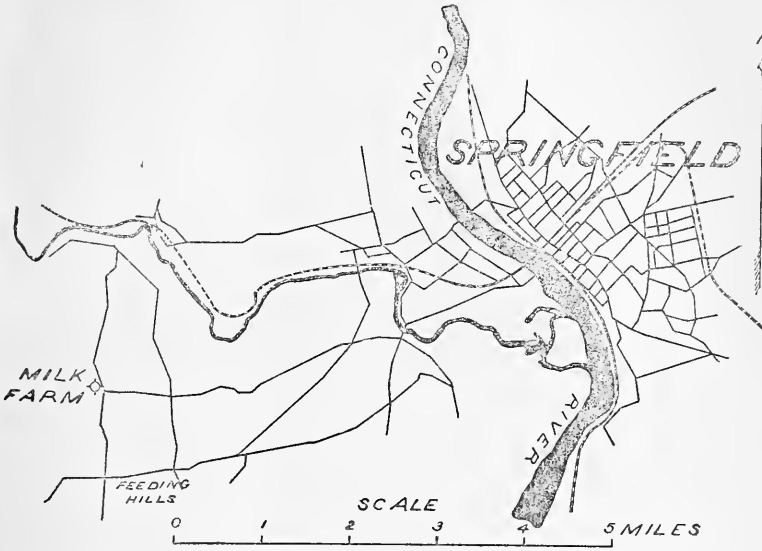
The inquiry was interrupted by the enforced absence of one of us, but was resumed on August 19.

The samples from the farmer's well in Agawam having shown no evidence whatever of infection, the problem seemed as puzzling as ever, when we were suddenly put upon what proved to be the right track by information showing that we had been grossly deceived by the milkman, and that in truth the Agawam milk was not the milk regularly served to the infected houses in the McKnight district.

It has been stated above that the milkman took one of us (W. H. C.) to all of the farms from which the milk that he sold "on the hill" came *except one* (see p. 717). We have since discovered that the milkman, probably in pursuit of a well-formed plan, took pains to drive the city physician first to the farms remotest from the one really to blame, and then to others in succession, until the latter grew weary of the apparently fruitless visitation of excellent farms. At last the milkman remarked to him that there was still one farm lying far to the westward and much out of the way homewards, from which he got some milk; but that "Dr. H—— had been out there, and everything was all right." In the belief that this was true, the milk theory, which up to that time had had no better basis than any other, was abandoned by W. H. C.

We now learned, however, that the latter had been deceived, and that the milkman, before he had become very seriously alarmed, had told Dr. H——, who was his family physician, that the milk which he was serving to the infected houses in the McKnight district was coming from the one farm to which he did not take the city physician on his round of inspection, and thus we had positive proof both of his duplicity and of the true source of the infected milk. We therefore immediately proceeded to the farm in question, which was located in Feeding Hills, and were rewarded by the discovery that upon this farm there had been one, and probably more than one, case of typhoid fever several weeks earlier. The location of

this farm, which we have every reason to believe was the source of the disease in Springfield, is shown upon the accompanying figure.



The farm was owned by a well-to-do farmer, who raised, among other things, tobacco, and kept a dairy. By inquiry we found that the farmer's daughter had had in the spring a case of "bilious typhoid fever." There was also a history of others upon the place "obliged to go to bed with slow fever," and it only remained to trace some possible connection between these cases and the infected milk. This we did not succeed in doing to our entire satisfaction, but we did find two possible avenues of contamination.

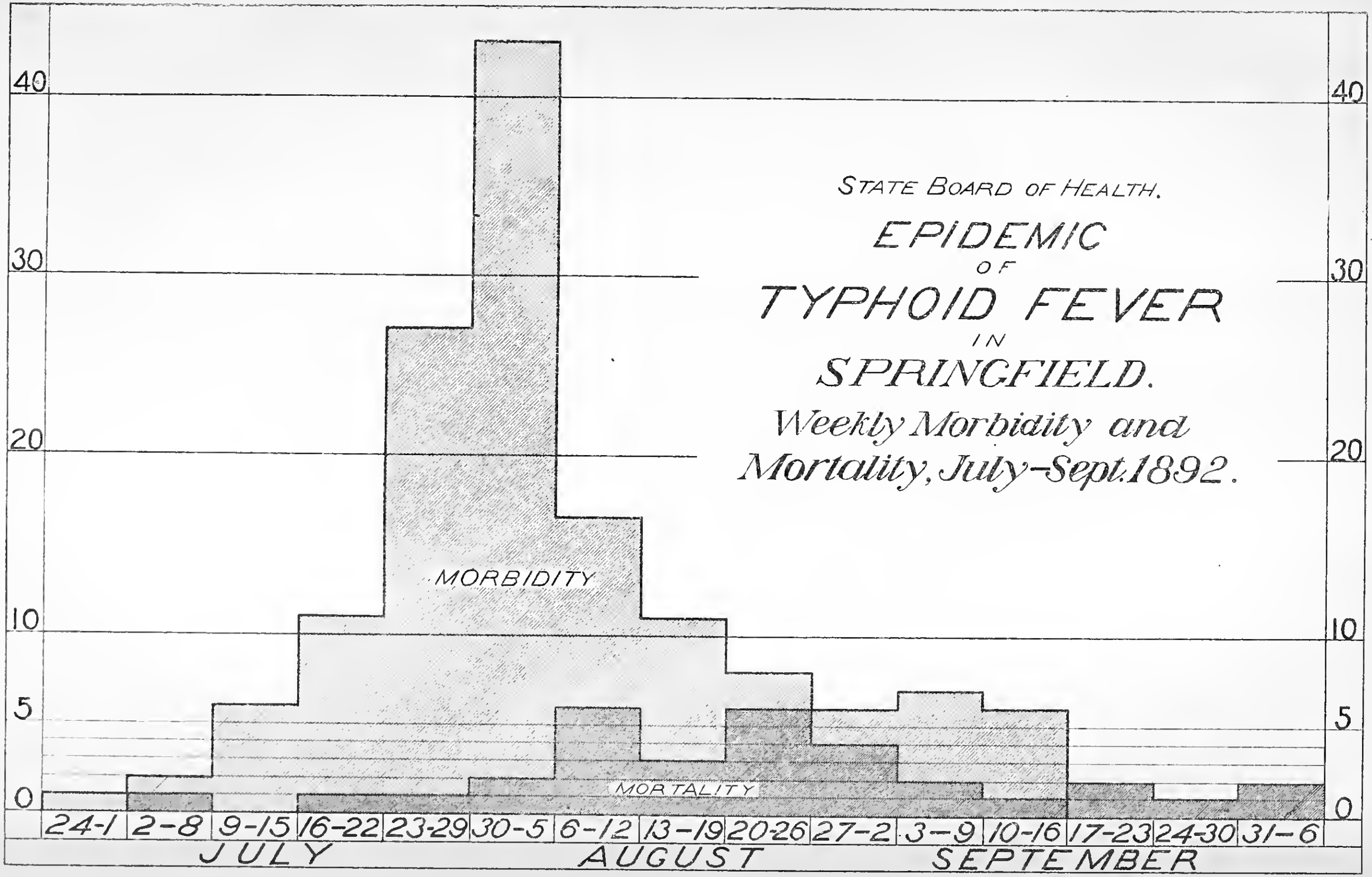
Most producers of milk for sale in cities cool the milk by allowing the cans freshly filled to stand in "coolers," surrounded by ice or iced water. In the present case the farmer had no ice, and therefore was in the habit of lowering the cans by means of ropes into a well adjoining the cow-yard. But unlike some of his neighbors, who hung cans in their wells just above the water level, this farmer *submerged* his cans, and allowed them to rest upon the bottom of the well, so that they were covered by from two to four feet of water. Here the morning's milk stood all day and into the evening, the evening's milk remaining if at all only a very short time before it was "collected" and carted off to arrive in Springfield, some six miles away, about midnight or a little later, to

be distributed at dawn, by the milkman referred to above (F. D. K.), to the consumers in the McKnight district.

At the time of our first visit to the farm we discovered the cans of morning's milk quietly reposing entirely out of sight on the bottom of the well. This was in most respects an ordinary dug well, but of unusually large diameter. It was covered with a platform of old and badly worn planks loosely laid on, and with rounded edges bordering on wide cracks. To allow the cans to be sunk and lifted, the planks were loose and separate. The cans were lifted by worn ropes, each of which ran through a hole in a plank and ended above in a large knot. On one side of the well was a chain pump, the spout of which overhung the platform, so that careless pumping easily washed matters on the planks near by through the wide cracks into the well. On the planks lay clumps of manure evidently left there by the dirty boots of the men. A little pumping proved that these were easily washed into the well; and, indeed, ordinary stepping about upon the planks to handle the milk cans or to pump must have cleaned the boots of the men at the expense of the water in the well.

On lifting the cans, on one of our visits, we found, by drawing them up and inverting them, that out of nine four leaked milk around the wooden stoppers with which they seemed securely plugged. Moreover, not one of them was *completely* full. On shaking the cans, the splashing of the milk inside was plainly heard. It was clear that if milk would leak out when the cans were inverted in the air water would leak in when the same cans were submerged in water. Thus by submersion the milk was not only cooled in temperature but to some extent augmented in volume. The well water was plainly dirty, and bacterial analysis showed it to contain *B. coli communis* in abundance, a form which testifies to the presence of fæcal contamination, at least of animal origin. There was no question in this case of pails or cans washed in infected water, for the former were washed in the house in mountain tap water, and the latter were steamed in Springfield.

This well, however, was at some distance from the house, and not used there for drinking. It was easy to see how, if the well were contaminated, the milk sunk in it might have become so. But how could the well have been connected with the cases in the house? A plausible hypothesis was the following: the excreta of the patients went into the privy, and there is reason to believe that they were not dis-


STATE BOARD OF HEALTH.
EPIDEMIC
OF
TYPHOID FEVER
IN
SPRINGFIELD.
Weekly Morbidity and
Mortality, July–Sept. 1892.
MORBIDITY
MORTALITY
40
30
20
10
5
0
24-1
2-8
9-15
16-22
23-29
30-5
6-12
13-19
20-26
27-2
3-9
10-16
17-23
24-30
31-6
JULY
AUGUST
SEPTEMBER

infected. The contents of the privy, shortly before the infection reached Springfield, were spread upon the tobacco field. From this field the workmen frequently passed to the well to get water and to work about the milk. It is not difficult to believe that in doing so they may have carried upon their boots masses of fæces, originally from the privy, from the field to the well, into which pieces fell through the cracks while the men trod upon the irregular planking. Whether or not this theory is true we shall probably never learn. An alternative hypothesis, moreover, remains. Upon most farms of this sort the "help" is constantly changing. Hired men only a few grades better than tramps come and go. There was a history of much of this kind in the present case, and it may easily have been that some such person acting for the time being as milkman was suffering from incipient or "walking" typhoid fever. In such a case a self-infection of the fingers, such as can only too easily happen, may have led to a heavy infection of the warm milk, such as must have existed in the milk which was served by F. D. K. to the McKnight district in Springfield.

The milkman (F. D. K.) for a time maintained with bold assurance that the milk from this particular farm had never gone to the infected houses; and therefore, in order to have independent evidence, we undertook a minute and systematic study of the somewhat intricate system of milk supply in Springfield. The problem was complicated by the fact that this particular milkman delivered from two separate wagons, and loaded these with milk from several dairies at two distinct points. But after many vexatious researches, including a visit by one of us (W. H. C.) to all of the dairies selling him milk, for the sake of obtaining documentary and statistical evidence of the dates and amounts of milk supplied by the several farms, delivered by the carriers and loaded upon each of his wagons, with the time of starting and the route of each, as well as the actual purchases of his wholesale customers, to whom he now affirmed that all of the Feeding Hills milk had always gone (thus contradicting flatly his original statement to Dr. H——); after interviewing his assistant, or "striker," who had delivered the milk; after having had the aid, also, of the able inspector of the Board, Mr. McCaffrey, — we at last obtained positive evidence from wholly independent data that the milk which went to the infected houses must have come, beyond a peradventure, from the farm in Feeding Hills. In all of this we were very greatly aided by the officers of

the Springfield Co-operative Milk Association, who courteously gave us access to their books and in many ways afforded us invaluable assistance.

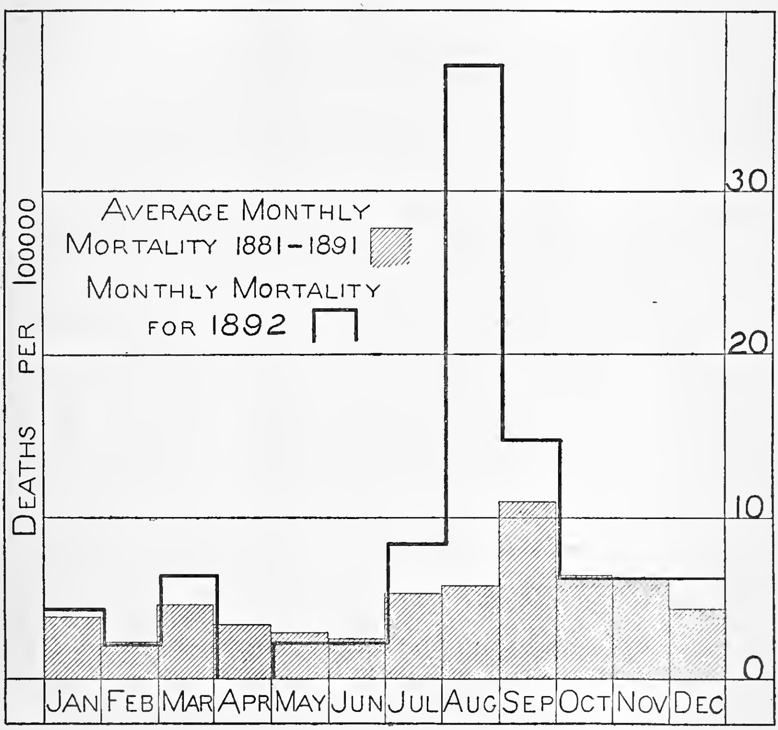
It now remains to describe somewhat more fully the epidemic itself. The location of the cases is indicated by the red circles upon the map. The houses (upon the hill) served by the milkman concerned are shown by the blue circles. It must not be forgotten that many other milkmen served other houses in this district, which is thickly settled, but in none of these was there any fever. The correspondence of the cases of typhoid fever with their milk supply is plain, although, as would be expected, some houses served by this milkman had no fever. There is good reason to believe that the infected milk was not the only kind that he carried, and that a different milk was sometimes delivered, *e. g.*, in the Ingersoll Grove district.

It will be observed that there were a few cases of typhoid fever in other parts of the city. A very few of these were imported. Of the others, those on Tenth and Essex streets deserve special comment. After the milkman became alarmed, he is known to have refused for a time to take milk from the dairy in question. We have positive evidence that milk from this dairy afterwards went to Essex Street; and that here, also, the fever appeared, is one of the strongest links in our chain of intrinsic evidence. Similarly, seven cases of typhoid fever suddenly appeared about August 20, in an hotel in the heart of the city; and while no positive evidence was found that milk from the infected dairy went to this hotel, we did discover that at the time when this milk was under a cloud, and was held by the Association, one can of reserved milk (ten quarts) was sold by them to that hotel, that this was an unusual occurrence, and at the very time required to have conveyed the disease to the hotel. As for the rest of the city, it was throughout the epidemic period almost wholly free from typhoid fever. The annual autumnal wave had not yet begun to rise.

The whole number of cases discovered and investigated was one hundred and fifty, the whole number of deaths belonging to the epidemic was twenty-five. The course of the epidemic may be seen upon the diagram of weekly mortality and morbidity opposite p. 722; its intensity, upon the diagram on p. 725 of monthly mortality from typhoid fever, which shows well also the limits of the epidemic

period. The intensity and exceptional date of the wave of mortality which followed the epidemic are also well shown by the diagram opposite p. 722. This exhibits the death rate from typhoid fever in Springfield by months for the twelve years, 1881–92. The

TYPHOID FEVER IN SPRINGFIELD.



MONTHLY MORTALITY (PER 100,000 INHABITANTS) FROM TYPHOID FEVER.

marked improvement since 1883 and the enormous excess in August, 1892, at the height of the epidemic, are notable. It will be observed that the death rate from typhoid fever during this month was by far the highest during any month of the entire twelve-year period.

Out of the whole number of cases one hundred and fifty, one hundred and one had milk sold by the same milkman (F. D. K.), while one hundred and thirty-five may have had access to the same milk.

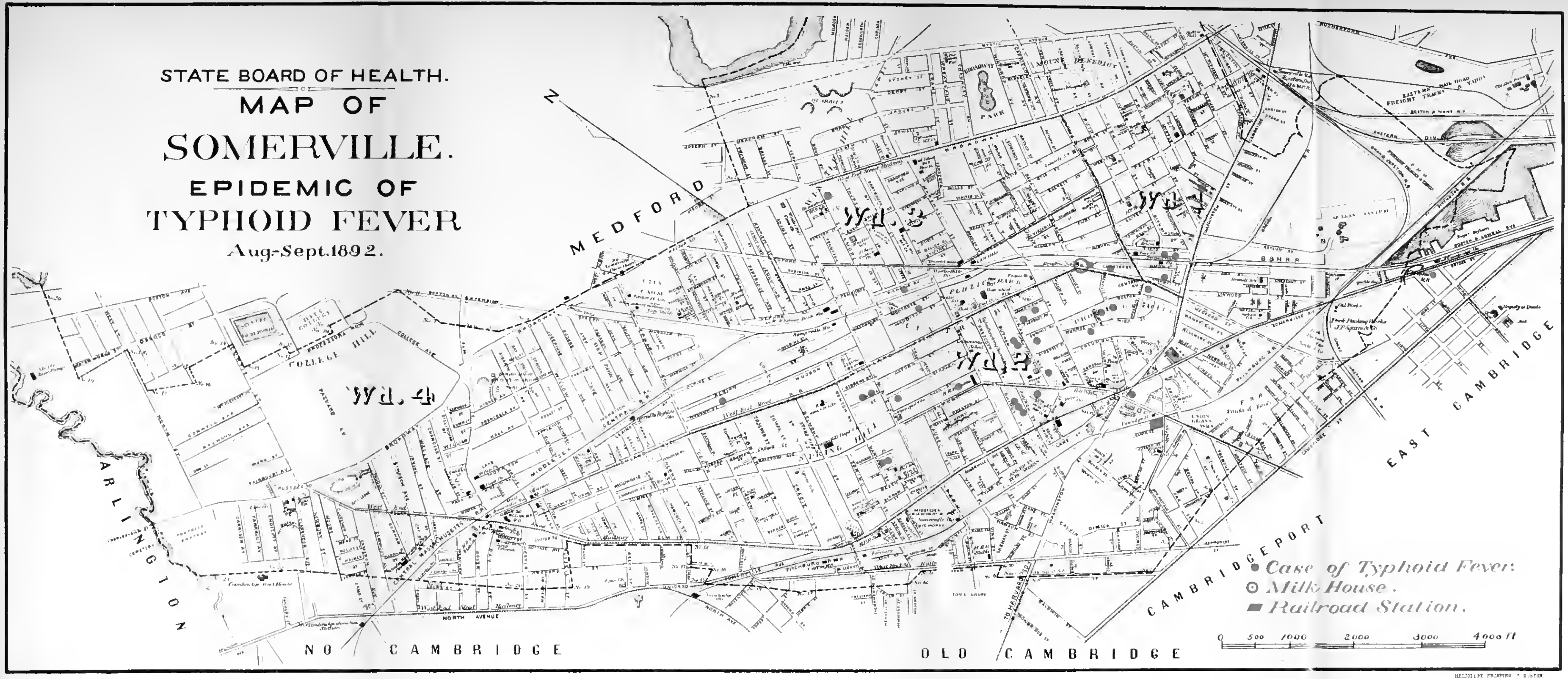
For aid in the preparation of the map, plates and diagrams we are indebted to Mr. R. D. Chase.

AN INVESTIGATION OF AN EPIDEMIC OF TYPHOID FEVER IN SOMERVILLE, DUE TO INFECTED MILK.

By WILLIAM T. SEDGWICK, Ph.D., Biologist of the Board.

(With Map.)

Towards the end of August, 1892, the attention of the Somerville Board of Health was drawn to a sudden and nearly simultaneous appearance of a number of cases of typhoid fever. The physicians reported the cases with commendable promptness, ten having been reported on August 23 alone, and an inquiry set on foot by the local Board of Health immediately revealed the fact that most, if not all, of the cases were served by one and the same milkman. Thereupon the Somerville Board reported the outbreak to the State Board of Health, and I was instructed to make an investigation. In view of recent experience in the Springfield epidemic, described in the previous paper, which I was still studying, I was able to work rapidly, and began by verifying the data already in hand. It afterwards appeared that during the three weeks, August 20 to September 10, there were in the entire city of Somerville thirty-five cases of typhoid fever. Of these one was imported, one was plainly a secondary case, a third was a very old case tardily reported. Thirty-two cases were apparently primary and indigenous and remained to be accounted for. Thirty of these had been served with, or had had access to, milk supplied by one and the same milkman. Of the other two cases, one was an old case of which the diagnosis was uncertain, though there was also a possibility that it was itself secondary to an earlier one; the other was synchronous with the epidemic period, and was that of a young woman who was in the habit of buying milk at a certain bakery. A bakery next door to the one from which she was in the habit of buying milk was supplied with milk by this particular milkman, and


STATE BOARD OF HEALTH.
MAP OF
SOMERVILLE.
EPIDEMIC OF
TYPHOID FEVER
Aug.-Sept. 1892.
MEDFORD
ARLINGTON
NO CAMBRIDGE
OLD CAMBRIDGE
CAMBRIDGEPORT
EAST CAMBRIDGE
Wd. 1
Wd. 2
Wd. 3
Wd. 4
Case of Typhoid Fever.
Milk House.
Railroad Station.
0 500 1000 2000 3000 4000 ft

the keeper of this bakery and her daughter were among the persons who suffered from typhoid fever. I could not get the young woman or her mother to admit that they had ever been in the nearer bakery which had the suspected milk; but as they had to pass it to get to their regular bakery, I cannot keep feeling that on some unusual occasion some member of the family had perhaps stepped into the nearer bakery and got some milk. This case coincided in time with the rest; but in view of the evidence I have considered it an unexplained case. The approximate location of the cases is shown upon the accompanying map.

The usual theories of water infection, sewer emanations, etc., were advanced by some to account for the outbreak, but were all easily disproved. The city of Somerville uses the "Mystic" water supply of the city of Boston, and this supply is not altogether unobjectionable but, inasmuch as the same supply served the whole city as well as the neighboring cities of Charlestown and Chelsea, while the present outbreak was confined to a limited area, the theory of wholesale water infection was easily disposed of. The region most affected was a fine portion of the city with the houses in excellent sanitary condition. There was no reason to suppose that the air, water, ice or sewers were worse here than anywhere else. The only common bond of connection between the infected families which was not also shared by thousands of others who were uninfected was the milk supply; and even this was shared by a large number of families in one portion of the city in which no fever appeared. It became necessary, therefore, before adopting the theory of infection by contaminated milk to show not only (1) how the milk might have become contaminated, but also (2) how it happened that only one portion of the milkman's route was affected with typhoid fever, while another and important portion was not so affected.

I addressed myself first to the problem of the infection of the milk, and after having interviewed the milkman at great length, for the sake of mastering the details of his business, visited the farms (in Littleton) from which the milk was said to have come. All of these proved to be free from typhoid fever, and to be examples of unusually decent dairies. From Littleton the milk was sent once a day to Somerville, arriving by train early in the forenoon at Union Square station the location of which is shown upon the map. I was further informed that from this point it was carried in a wagon, still in the cans used for shipment, holding eight and one-half quarts

each, to a kind of barn called the "milk house" (also indicated upon the map), near the residence of the milkman. I was also told that in the milk house the milk was "mixed" by being poured from the large cans into the mixer, a capacious upright metal tank provided at the bottom with a faucet. After mixing (to produce an even grade) the milk was drawn off into the small cans supplied to consumers, these being next stoppered with wooden plugs and finally set away in the ice box, where they were "iced" and stored until early the next morning. At daybreak or earlier these small cans were delivered to the consumers by means of two wagons, each having a special route and a special series of customers. Inquiry showed that in proportion to the number of takers the cases were about equally distributed upon the two routes, which indicated that the infection must have existed in the mixer or in the cans, or possibly in both. The milkman-in-chief had two sons, one of whom was lying dead of typhoid fever when I first arrived on the spot. The date of the report of his case, however, agreed closely with that of the other sufferers from the disease, and he was also said to have been a great drinker of milk, so that he appeared to be simply a sharer in the common calamity. This son (W. B.), I was told, drove one of the wagons and worked in the milk house, but never handled the milk. It was his duty merely to wash the cans, while his brother, who drove the other wagon, "handled" the milk. This brother was not attacked by the disease.

Thus far it appeared that the milk had unquestionably arrived in the city uninfected, and had been carried in the unopened cans directly to the milk house, still uninfected; but when it left the milk house in other cans, some of it, at least, must have been infected. There was but one logical conclusion, namely, that it had somehow got infected in the milk house. I therefore investigated more closely the case of the son (W. B.) who had just died of typhoid fever, and was rewarded by the discovery that, although his case had indeed been promptly reported by his attending physician, and thus apparently belonged with the rest, it was in reality much older than the others, and dated from a time early enough to allow him to have contaminated the milk, and thus to have been the unfortunate cause of the whole trouble. This young man had first consulted another physician, who had failed to inform him of the true character of his disease, and, instead of putting him to bed, had allowed him to keep on with his work until finally the fever

affected him so seriously that he could hardly keep his seat on his wagon, and at last, in desperation, consulted a competent physician. Then, and not before, his case was recognized and reported, and he was sent to bed; but so far was the disease advanced that the next day he had one intestinal hemorrhage, followed before long by others of great severity; and very soon after he died.

It is plain that this young man worked in the milk house about, if not at and over, the milk, until he was in an advanced stage of the disease. It was denied by his father and brother that he ever "handled," or, as the phrase is, "set up," the milk, *i. e.*, transferred it from the large cans to the "mixer" and then to the little (consumers') cans. It was alleged that his office in the milk house was simply to wash the cans, never to set up the milk. This point was urged upon me with eagerness and persistence, as fatal to my theory; but without discrediting the honesty of the affirmation, I cannot readily believe from what I have seen and learned of the milk trade, milkmen, milk houses, etc., that a division of labor really existed in this case so complete as would be required to exclude all possibility of infection of the milk by a sick man working within a few feet of the "setting-up" process, and doubtless ready and willing to lend a hand. I do not believe that, when two men are working day after day over milk in one room, one man always and without exception washes cans, while the other always and without exception puts milk into cans.

As to the precise way in which such a person might contaminate the milk there is no difficulty, even if he were only a washer of the cans. If such a person, in the early stages of the disease, affected with diarrhœa, should merely fail to wash his hands on returning from the privy and should then proceed to wash cans or to help in emptying the cans into the "mixer," particles upon his fingers might drop or be brushed or washed off into the milk. That many people do habitually omit to wash their hands under similar circumstances is a fact.

In spite of these important discoveries, there still remained for some time a very serious objection to the theory that the milk had really been contaminated at the milk house. In the vicinity of Union Square (see map) and to the east and west of this region the same set of milkmen delivered a considerable quantity of milk and served a large number of customers. Here, however, there had been no typhoid fever. I was myself much puzzled by these facts

from the start and the milkman-in-chief lost no opportunity of urging them upon my attention as an insuperable objection to the milk-infection theory. At last, however, in the over-eagerness of his argument, he himself afforded the clew which enabled me to solve the whole difficulty. In reiterating the importance of the absence of cases upon that portion of the route near Union Square, and saying that more of the milk went thereabouts than on the hill (where the cases had occurred), he added that he knew this because he "*always waited around after the train came and gave the boys several cans off the wagon*" which they sold directly to the uninfected districts. Immediately everything became plain. These districts had evidently not been infected, *because they had not usually had milk from the milk house*, but had been served with fresh milk just in from Littleton; probably only enough was taken from the train each day to serve these customers and those upon the hill who would not wait for the train to arrive next day. No more would be carried over than was necessary, because if the supply ran low more could be got in time for use, next day; and milk in August does not keep well. This milkman's route extended over the line into Cambridge, in which city he served three families. I was interested to find in one of these, a case of typhoid fever (see map) synchronous with those in Somerville. There was no other case in Cambridge anywhere near this point at that time.

One of the most interesting features of the epidemic was the indication which it afforded that in the very early, and possibly even in the prodromal, period of typhoid fever the patient must have been discharging the germs of the disease. His case was believed by two thoroughly competent physicians who saw him to have been well on "in the third week," on August 28. His first hemorrhage, so far as is known, was on the 29th, and he died September 6. The cases first began to appear on the 16th, on which day physicians were called to five cases in Somerville; and seventeen out of the whole number of cases had their first visit from the physician on this day or one of the four following. Previous to this there had been only one case in Somerville since August 5. It would appear from a consideration of the epidemic itself that the milk must have been most heavily infected between the 1st and the 10th of August; and we have every reason to believe that at this time one of the milkmen was in the early stages of the disease. This is the more interesting because the great epidemics in Lowell and Lawrence in

1890–91 were apparently due to excreta thrown off in the early stage of the disease, before the patients took to their beds. The same thing was true of the epidemic in 1892 in Chicopee Falls, and also in the important epidemic in Red Hill and Caterham (Eng.) in 1879. In the present case I was told by his father that the young man had not been able to do anything at the milk house "for a week or so" before he ceased to deliver milk and went to bed; *i. e.*, not after about August 20. The last case had its first visit from the physician on September 3, or exactly two weeks afterwards. In other words, after this young man no longer visited the milk house the epidemic ceased. Later in September there were one or two more cases of typhoid fever in Somerville, but they proved on investigation to have been imported, having obviously contracted the disease elsewhere.

My thanks are due to several of the physicians of Somerville for their valuable assistance, especially to Medical Examiner Dr. T. M. Durell and Dr. William A. Bell.

INVESTIGATIONS OF EPIDEMICS OF TYPHOID FEVER IN BONDSVILLE, PROVINCETOWN AND MILLVILLE, APPARENTLY DUE TO SECONDARY INFECTION.

By WILLIAM T. SEDGWICK, Ph.D., Biologist of the Board.

(With Map.)

I. An Epidemic of Typhoid Fever in Bondsville.

Bondsville is one of several small villages in the township of Palmer and lies upon the Swift River, one of the three main tributaries of the Chicopee. Its situation is indicated upon the map of the drainage area of the Chicopee River already referred to above in the paper of Mr. McLauthlin upon the epidemic in Chicopee Falls. On Sept. 1, 1892, as I was about leaving Springfield after making the investigations recorded in a preceding paper, my attention was called to an outbreak of typhoid fever in certain tenements belonging to the Boston Duck Company in Bondsville.

On arrival I found there eleven cases of typhoid fever, and conditions which demanded immediate attention. The fever was confined to a small section of the northern extremity of Bondsville, sometimes called Duckville. In the main village there were no cases, and in Duckville there were then no cases on the main street. The accompanying map of that portion of Bondsville will serve to show the location of the earlier cases, which, as appears from the numbers on the map, were upon or near High Street and Maple Street. The houses on High Street are double wooden tenements, with double privies in the rear to correspond. A five-tenement house stands west of and parallel to High Street, between the latter and Main Street. The two houses on Maple Street are similar to those on High Street. There is also one house (containing case No. 18) really on Front Street, but connecting more closely with

Maple Street by a footpath. In all, the tenements upon High Street and Maple Street, with that last mentioned, are thirty-one in number. In this small group of houses there were during August and September, 1892, nineteen cases of typhoid fever and two cases which were pronounced by the attending physician to be malarial fever. Twelve out of these thirty-one tenements contained cases of fever, while nineteen are not known to have been affected. A large boarding-house for employees of the Boston Duck Company stands upon High Street near the infected district but, so far as known, had no cases of typhoid fever in it at any time. High Street and Maple Street are on somewhat higher ground than Front Street, and the latter contains a population somewhat more well-to-do. Front Street and Spring Street have together as many people as High Street and Maple Street, or more; but at first there was no fever upon these streets, and when it did finally appear there it was limited to six cases. The people upon Front Street are of a somewhat higher class, and have no dealings with those on High Street, except in the mill and at school or church.

I found on my arrival that there were two prevailing and rival theories extant for the cause of the trouble. The first was that a much-used well, the location of which is shown upon the map, on the east side of High Street (and which is really further east than is indicated), had become infected from the neighboring privies. These were only about thirty feet distant, and very objectionable. It appeared that this well had long been the favorite source of water supply for the entire High Street and Maple Street neighborhood. When typhoid fever broke out on High Street the cases were not far from this well, and had made use of its water. The agent of the mill, who had long regarded the well with suspicion, immediately had the handle removed to prevent its further use and sent a sample of water to a chemist for analysis. The people meanwhile fell back upon the tap water with which these tenements are supplied, or rather, because the tap water sometimes has an objectionable taste and is therefore very unpopular with them, resorted to more distant wells. The dwellers upon High Street and Maple Street on the other hand, unanimously attributed the fever to the tap water, although they all insisted, as one man, that it was so very bad they never had used any of it for drinking.

When the chemist returned his report he completely exonerated the well, and therefore, after having had a confirmatory analysis

made, the agent reluctantly yielded to the importunities of the people, and restored the pump handle. On my arrival the well was in use as hitherto, but so very suspicious was the situation of the well that I, also, felt confident that here must be the real source of the fever. I therefore had the curb lifted, and soon found that it was a "driven" well, sunk to a great depth. I secured a sample of this water, as well as of the tap water, and having had the handle of the pump once more removed, began a careful investigation.

It very soon appeared that the cases were by no means synchronous, but showed a peculiar and interesting succession. At the same time other serious objections to any theory of water-infection began to appear. In the first place, the tap-water theory was untenable, because (1) although this water was supplied only to the small district in which the fever appeared, and to the bleachery (as may be seen by following upon the map the broken line coming from left on Front Street), and was therefore curiously connected with the infected houses, it was plain that but little if any of it had been used for drinking, on account of the prejudice against it referred to above; and (2) because many of the tenements supplied with it, as well as the very populous boarding-house, had been entirely exempt from the fever. So, also, was it with the well-water theory; for, while at first this looked extremely plausible, it was difficult to see, first, how, if the well had been really infected, more cases had not developed, for it was used by everybody; and, second, if it were really infected, why the cases were so strangely successive and not simultaneous. Besides all this, opposed to both theories, was the fact that there was absolutely no evidence of any specific contamination of either tap water or well water in either the near or the remote past. When, therefore, the bacteriological and chemical examinations revealed the fact that both waters were, considering the circumstances, remarkably pure, both theories of water infection necessarily fell to the ground.

I next made a careful study of the milk supply, which showed that the infected families had several different milkmen. Here, also, the remarkable succession of the cases was a serious objection to the theory, and, finally, the milk theory also, being entirely unsupported by any evidence, had to be abandoned.

In the course of the investigation I had already observed some striking examples of the possible methods of secondary infec-

tion in the tenement containing cases 9, 12, 15, 16. Some of the other cases were also plainly secondary, and I therefore made a careful study of the dates of the several cases and of the local sanitary conditions. As a result I was finally forced to conclude that from one imported case, favored by the peculiar constitution of the little community and its habits, the fever had slowly spread by secondary infection, until it finally reached Front Street. The following table will show the succession of cases, and, if this be read in connection with their location upon the map (see map), it may serve as an unusually clear and interesting example of the growth of an epidemic of typhoid fever apparently due to secondary infection. It is noteworthy that many of the patients were children.

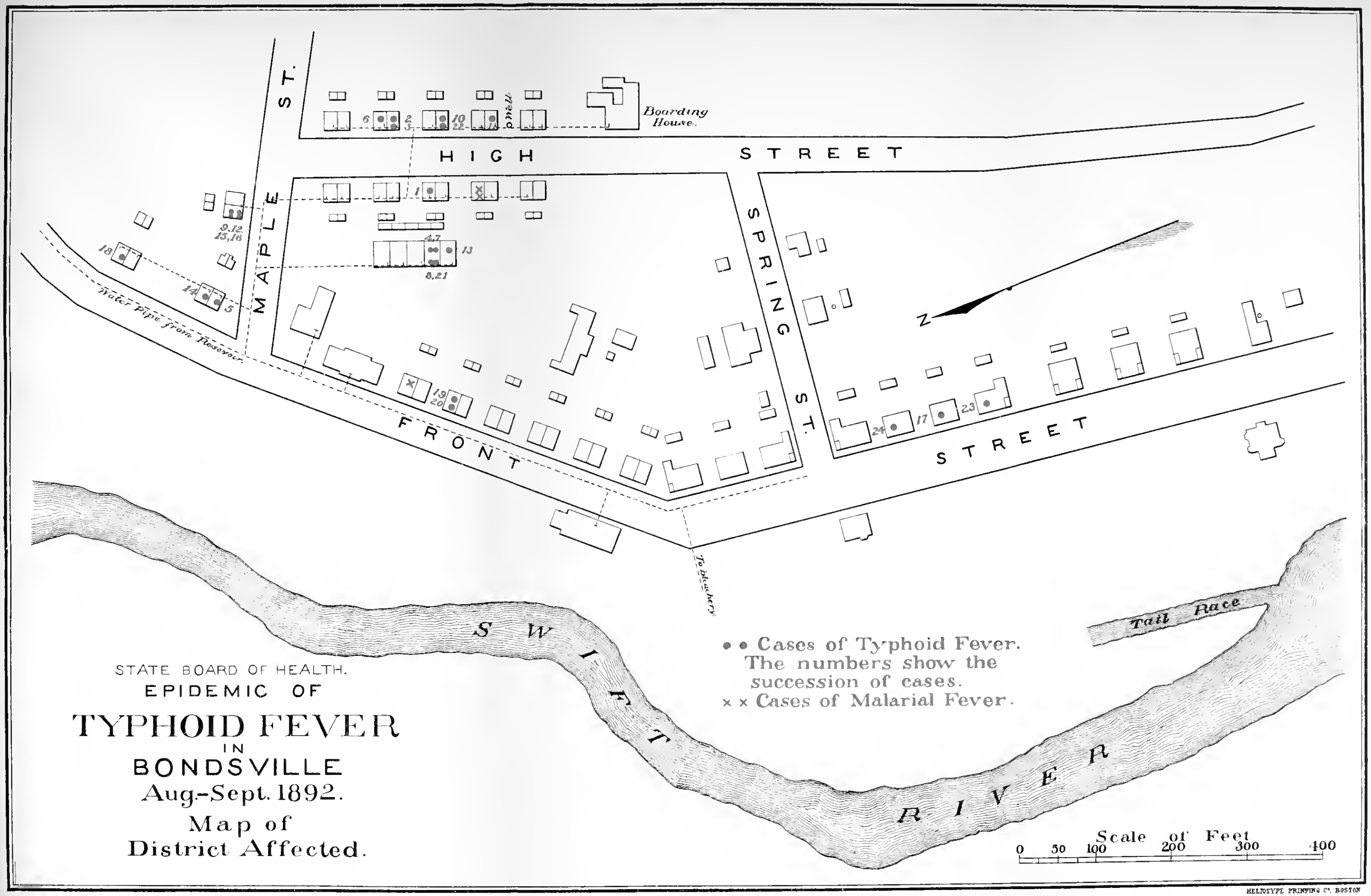
Typhoid Fever in Bondsville.

The Succession of Cases during the Epidemic.

Number of the Case.	Name of the Case.	Date of the Case.
1	Victoria Côté,	Aug. 1-5
2	Mike Kennedy,	11
3	Patsy Kennedy,	13
4	Eddie Fitzgerald,	13
5	Johanna McEllicott,	14
6	Dan. Sullivan (died Sept. 8),	15
7	Martin Fitzgerald,	16
8	Patsy Fitzgerald,	16
9	Morris Moriarty,	20
10	Phileas Beauregard,	24
11	Louis Pilon,	26
12	Mrs. Moriarty,	27
13	Midas Brunelle,	30
14	Johnny Lyons,	Sept. 3
15	Tommy Moriarty,	4
16	Thomas Moriarty,	7
17	James Rickerts,	12
18	—— —— (a Polish girl),	14
19	Nora Scanlon,	15
20	—— Scanlon,	16?
21	Jimmy Fitzgerald,	20
22	Mrs. Pilon,	27
23	—— Farr,	29?
24	—— Conlin,	30

The "date of the case" was, as usual, either the date "of going to bed," or, more often, of the "physician's first visit." Some of the victims were French, some Irish; all or nearly all went to the same school and attended the same church. The adults of the two nationalities in this little community live in friendly, but not intimate, relations; the children, on the other hand, play constantly together, and wander freely from house to house; they are at home in all of the houses in which there are any children. On High and Maple streets live about one hundred and fifty people. Children abound; and, as there are no fences, and because it is the custom, they mingle freely, playing together and passing from house to house. The families are of that grade in which food always stands upon the table; meals are irregular except for those who must obey the factory bell. The children play awhile, then visit the privies, and with unwashed hands finger the food upon the table. Then they eat awhile, and return to play. Or, changing the order of things, they play in the dirt and eat and run to the privy, then eat, play, and eat again, and this in various houses and in various privies. For them, so long as they are friendly, all things are common, — dirt, dinners and privies; and, to illustrate exactly how secondary infection may go on, I may describe in detail one case which I personally witnessed. A whole family (of six or more) was in one room. Four of them had the "fever." Two of these were children in the prodromal stage. A table stood by the window covered with food, prominent among which was a big piece of cake. It was early September, and a very warm day; but every window was shut and the odor was sickening. Flies innumerable buzzed about, resting, now on the sick people, now on the food. A kind-hearted neighbor was tending the baby. By and by one of the children having the fever withdrew to the privy probably suffering with diarrhœa, but soon returning, slouched over to the food, drove away some of the flies, and fingered the cake listlessly, finally breaking off a piece, but not eating it. Stirred by this example, another child slid from his seat in a half-stupid way, moved to the table, and, taking the same cake in both hands, bit off a piece and swallowed it. The first boy had not washed his hands, and if the second boy suffered from secondary infection, I could not wonder at it.

This was one case; but I have seen so often the table of food standing, hours long in the kitchen and serving as one station in the dirty round of lives like these, that it is easy for me to under-



HIGH STREET
MAPLE ST.
SPRING ST.
FRONT STREET
Boarding House.
Well
Water Pipe from Reservoir.
To Bleachery
N
SWIFT RIVER
Tail Race
● ● Cases of Typhoid Fever.
The numbers show the succession of cases.
× × Cases of Malarial Fever.
Scale of Feet
0 50 100 200 300 400
STATE BOARD OF HEALTH.
EPIDEMIC OF
TYPHOID FEVER
IN
BONDSVILLE
Aug.-Sept. 1892.
Map of
District Affected.
HELIOTYPE PRINTING Co. BOSTON

stand how dirt, diarrhœa and dinner too often get sadly confused. Personal filth is apparently the principal agent of secondary infection.

Thus far I have not even touched upon one feature of the life of this little community, which deserves careful consideration. There was for most or all of these houses a sewer connection *for the sinks but not for the privies.* Much, perhaps most, of the garbage found its way into the privies. These had been obviously in bad condition, and, from some, filthy streams ran down between them and the houses. In and around these streams the children played. Given any original imported case, the infection might easily have reached these trickling streams. Children's fingers might thence carry the germs to the food, and thus the journey of the germs from one living intestine to another be completed. Or, again, given in such a community an imported case and no disinfection, as was the condition here at first. The importer while in the early stages handles with unclean hands food for others; or the clothing of such a person gets infected and is handled; there need be then no difficulty in completing the history. It follows as a matter of course.

I have been thus specific in this case because I am firmly persuaded that many so-called "sporadic" appearances of typhoid fever originate in these ways; and surely it is more reasonable to think so than to imagine a spontaneous generation of anything so specific as an infectious disease.

Before leaving the village on the day of my first visit (September 1) I urged upon the agent of the mill, who was also one of the selectmen of Palmer, the gravity of the situation, and the urgency of proper disinfection. I also advised that a competent physician be appointed as temporary health officer, to see that disinfection was properly done. On making a second visit, about three weeks later, I found that my advice had been followed, but that disinfection had not been thorough enough; for, although I had been informed that there were "no new cases," I discovered no less than ten new ones. I therefore addressed to the chairman of the selectmen of Palmer the following letter: —

BOSTON, Sept 21, 1892.

DEAR SIR: — I visited yesterday, for the second time, the district in Bondsville affected by typhoid fever, and was gratified to learn that your Board had acted promptly in accordance with my advice of September 1,

viz.: to appoint a competent physician as health officer, who should watch the epidemic closely, secure proper disinfection of excreta, etc. In spite of all that has been done, however, the disease appears to be slowly advancing, mainly, if not wholly, by what is known as "secondary infection," i. e., by infection from the earlier cases. In the Moriarty family, for example, where on September 1 I found only one case, there are now at least two more; in the Fitzgerald family, where there were two cases, there are now three or four. New cases have also appeared in houses adjoining those first affected, as, for example, in the tenement occupied by the Lyons family, and that behind it and not far from the Moriarty's, occupied by a family of Poles.

The disease was at first strictly confined to the group of tenements in which it began, but it has now reached the outskirts of this area, and has appeared in two places on the principal street, previously uninfected. For these and other reasons I would respectfully urge upon your Board still greater activity in the matter, and would recommend that the health officer appointed by you be authorized and instructed to disinfect such tenements as shall seem to him to require it, by the most thorough cleaning and in other ways. I am of the opinion that the only immediate danger in Bondsville lies in the uncleanness of the people and the filth of the infected houses, so that in families such as I have specified the germs of the disease are conveyed to the food of the family (with which they are swallowed) by dirty and tainted hands, dirty dishes, pulverized fæcal matters and the like, as well as by the swarms of flies which infest these houses. You will observe that these are conditions which may be ameliorated if not wholly removed by cleaning and other disinfection.

Inasmuch as many of the families affected are French, I would also suggest that Dr. Auger be associated with Dr. Smith, as health officer, to aid in the work of disinfection. I have addressed this note to you instead of Mr. Getchell, with whom I have communicated hitherto, as he is away upon a vacation.

Respectfully yours,

WM. T. SEDGWICK,

Biologist, State Board of Health.

To the First Selectman and Chairman of the Board of Health, Palmer, Mass.

To this I got no reply. On another visit I learned that my letter had been received, but never acted upon. I understand also that there were afterwards only a few more cases.

In spite of the large number of cases, twenty-four or more, there was but one death. I have observed a similarly small fatality in some other epidemics of secondary infection, in marked contrast to what usually happens in epidemics due to milk or water infection. This

may very likely be due to the moderate amount of infectious matter swallowed, or, possibly, to its half-dried condition in some cases.

There is reason to believe that the original case (No. 1) was imported from Ware. The patient had been visiting a French family in Ware where "there had been sickness," and where "the water was very bad." Communication between Ware and Bondsville is easy, by railway, and Ware has long been noted for its excess in typhoid fever. At the same time I did not establish with absolute certainty any such connection.

My thanks are due for much valuable aid to the physicians of Bondsville, especially Dr. H. M. Auger; and to Mr. C. E. Getchell, agent of the Boston Duck Company.

II. An Epidemic of Typhoid Fever in Provincetown.

On Oct. 8, 1892, I visited Provincetown at the request of the State Board of Health, to investigate a small outbreak of typhoid fever which had appeared there. In company with Dr. Birge of the local Board of Health, I examined the local conditions, and found that all of the cases, about twelve in number, lay within a limited area, in which typhoid fever had not usually prevailed. The victims were all, or nearly all, Portuguese. By the usual methods the milk supply and the water supply as adequate causes were excluded, and the conclusion was reached that the fever had been spread in a slow way, and to a limited extent, by secondary infection. Here, as in Bondsville, the children of various families play and eat much together. Here also the food is exposed and fingered; and here also it was easy to see how the infection, once introduced, might have spread far and wide by food and fingers. Inasmuch as the case was in no essential particulars different from that in Bondsville, it need not be further considered.

III. An Epidemic of Typhoid Fever in Millville.

The town of Blackstone comprises several villages, one of which is Millville. Here the Woonsocket Rubber Company has a large mill, employing twelve hundred to fifteen hundred operatives, nearly all of whom are men. A felt factory, tributary to the boot factory but to some extent independent of it, is located near by, and employs about two hundred hands. About one thousand operatives live in Millville, the others dwelling in Woonsocket, Blackstone and other places in the vicinity. The operatives are of various nationalities, including Irish, Swedes, Finns and a few French.

In October, 1892, typhoid fever had become epidemic in Millville, chiefly among the Swedes and Finns. It had been gradually spreading for a long time, until finally much anxiety and even alarm was aroused, which found expression in the following notice, publicly posted in the rubber mill: —

NOTICE.

MILLVILLE, MASS., Oct. 28, 1892.

All persons employed in this factory who are living in houses where there is anybody sick with the fever, must immediately move out of such houses, or else stay away from the factory until the fever has left the vicinity where they are living.

After this date, no persons will be allowed in the factory who are living in contact with those sick with fever.

This is to protect the health of employees.

Per order,

WOONSOCKET RUBBER COMPANY.

This notice created much ill-suppressed excitement in the village, led to the concealment of cases, lest loss of employment should follow, and added materially to the general alarm. This was still further heightened by the tone of a daily newspaper much read in the village, which made the most of every new case and of every death. At length the State Board of Health was appealed to, and I was sent to investigate. On the day of my arrival, October 29, I found the village in a state of alarm bordering on a panic. On the same day two poor families of Swedes had gone so far as to abandon their dead, having fled in abject fear from the houses where the corpses were lying. I immediately set to work to quiet the people, caused an article to be published in the above-mentioned newspaper, explaining in simple language the exact character of the disease and how to avoid it; secured through the local Board of Health proper care for the dead and disinfection of the houses; met the directors of the rubber works, and had revoked the objectionable "Notice;" and advised the local Board to appoint a temporary health officer with power to engage a competent nurse to care for the sick and apply disinfectants at the public expense.

A careful study of the cases followed, in which I was greatly aided by Dr. Melifant, one of the members of the local Board of Health, and afterwards, at my suggestion appointed health officer, who had had under his care a large majority of those affected. It appeared that the trouble began with the arrival of an imported

case, an immigrant just landed in America by way of Boston, who had had "ship fever" at the time of leaving the steamer. He was a poor Swede, and from him the disease had apparently slowly spread by secondary infection, first among those of his own nationality and in or near his boarding-house, and finally to some of other nationalities. There was absolutely no evidence of polluted milk or water as vehicles of the disease. Moreover, although it was freely charged that the mill privies had been active agents in spreading the disease, there was no evidence pointing in that direction. Those operatives of the mill who were living in Blackstone or Woonsocket did not suffer in any unusual degree from typhoid fever, nor did those in Millville, excepting the Swedes and afterwards "Russian Finns."

To show the peculiarly sluggish and long-continued character of the epidemic, the following dates of Dr. Melifant's and Dr. King's cases up to the time of my visit may be given: —

The first case was J. A., an immigrant Swede, arrived two or three weeks previous from a ship said to have had "ship fever" on board. He was first seen on June 7. The next case was also a Swede, H. L., living near by, on June 15. Cases then followed on these dates: June 18 (2); June 20; June 23; June 25; July 1; July 3; July 5; July 6; July 10 (2); July 11; July 12; July 13; July 15; July 18; July 20; July 23; July 27; July 30; August 6; August 10; August 20 (2); August 22; August 26; August 30; September 1; September 4 (2); September 6; September 8; September 15; September 17; September 18; September 20; September 23; September 26; September 29; October 1; October 5; October 9; October 10; October 11; October 12; October 13 (4); October 14; October 15 (2); October 29. Many of these were plainly secondary cases from others in the same tenement or boarding-house.

Between June and November there were in all at least one hundred cases and twenty-five deaths. The high mortality was probably due not so much to the severity of the disease as to utter neglect and dire poverty. The local conditions were very bad, and the people mostly very poor. The circumstances favored the spread of the disease by secondary infection, and to that, in my opinion, the epidemic was almost wholly, if not entirely, due. The dates of the cases, the crowding together in tenements and in cheap boarding-houses, the prevalence of the disease almost exclusively among the Swedes,

in whom it first appeared and who, in Millville, are decidedly clannish; and its absence from their neighbors of other nationalities with whom they had no dealings, all pointed to its sluggish spread by secondary infection.

The local Board of Health promptly adopted and acted upon my advice, appointed Dr. Melifant health officer with full powers, provided a male nurse to enforce disinfection under his direction, and supplied disinfectants freely at the public expense.

When, on November 5, Dr. R. W. Greenleaf of Boston was sent by the State Board of Health to tender medical aid on its behalf, he found the panic ended, the process of disinfection faithfully carried out, and no new cases appearing.

It only remains for me to record my deep obligation to Dr. Melifant for his courtesy and his valuable assistance.

HEALTH OF TOWNS.

HEALTH OF TOWNS.

The following digest is compiled from such reports of local boards of health as are received at the office of the State Board.

An examination of these reports shows that, as population increases, the demands of the people for improved methods of sanitation are in many instances answered by increased appropriations and better work on the part of local boards for the protection of the public health and the prevention of infectious diseases.

In the last report of the State Board the suggestion that local boards of health should be required to report to the State Board such cases of diseases dangerous to the public health as were reported to them received favorable attention from the Legislature, and resulted in the enactment of the following statute: —

[ACTS OF 1893, CHAPTER 302.]

(1) When the board of health of any city or town has had notice of the occurrence of a case of small-pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the state board of health of the same.

(2) If the board of health of the city or town, in which a case of small-pox or any other disease dangerous to the public health has occurred, refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

The result of the enactment of this law will be reported upon in the next annual report of this Board.

In the report of last year a table was introduced in which for the first time the number of cases reported to local boards of health were compiled, and a summary of the same was presented. The following summary presents the same data for the year 1892: —

Reported Cases of Infectious Diseases.

	Diphtheria.		Scarlet-fever.		Typhoid Fever.		Measles.	
	1891.	**1892.**	**1891.**	**1892.**	**1891.**	**1892.**	**1891.**	**1892.**
Reported cases,	2,444	3,033	4,517	6,112	2,414	1,892	5,861	783
Reported deaths,	575	891	151	281	460	435	84	31
Percentage of deaths to reported cases,	23.5	29.24	3.34	4.60	19.05	22.99	1.4	3.96
Mean of two years,	26.76		4.06		20.78		1.73	

The foregoing table shows a considerably increased number of reported cases of diphtheria and scarlet-fever, as compared with the figures of 1891; while the number of reported cases of typhoid fever was considerably diminished, and those from measles were very greatly diminished. The percentage of fatality was in each instance considerably increased. These differences in fatality in different years agree fairly well with those of England, in which similar variations are reported.

The percentages published by the Local Government Board are as follows for 1890 and 1891: —

	1890.	**1891.**
Diphtheria,	25.5	23.7
Scarlet-fever,	8.0	5.8
Typhoid fever,	19.9	20.8

The number of cities and towns in Massachusetts from which these reports were compiled was 73, and the population of these cities and towns was about 1,600,000, or nearly 70 per cent. of the total population of the State.

The following table presents in detail the number of reported cases and deaths from each of the four specified diseases in the cities and towns embraced in this summary: —

Summary of Certain Infectious Diseases reported to Local Boards of Health.

Cities and Towns.	Diphtheria.		Scarlet-fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Amesbury,	35	-	34	-	19	-	-	-
Attleborough,	8	2	14	-	26	8	-	-
Belmont,	-	-	22	2	1	-	3	-
Beverly,	5	-	31	-	-	-	-	-
Boston,	1,353	414	374	17	80	15	-	2
Bradford,	6	1	9	-	18	4	26	-
Bridgewater,	-	-	64	1	1	-	-	-
Brockton,	33	14	62	2	22	8	28	-
Brookline,	8	4	74	-	13	1	14	-
Cambridge,	130	56	374	17	80	15	-	2
Canton,[1]	-	-	57	-	-	-	-	-
Chelsea,	45	14	155	13	24	10	-	-
Chicopee,	-	1	-	7	many	24	-	-
Concord,[2]	8	-	11	-	9	1	69	-
Cottage City,[3]	-	-	-	-	-	-	-	-
Danvers,	4	-	40	-	5	-	-	-
Dedham,	-	2	-	-	-	2	-	-
Easthampton,	21	5	36	-	1	-	2	-
Everett,	22	9	87	3	7	1	26	0
Fall River,	68	34	223	29	100	24	-	7
Fitchburg,	16[4]	4	46	1	18	1	30	1
Framingham,	11	1	28	7	14	2	14	-
Franklin,	-	-	-	1	-	2	-	-
Gardner,	6	3	46	-	6	2	95	-
Gloucester,	40	1	209	4	18	3	-	-
Greenfield,	16	3	19	-	6	1	-	-
Hanover,	-	-	9	-	-	-	-	-
Haverhill,	27	-	107	5	62	12	17	-
Hingham,	5	-	13	-	-	-	-	-
Holyoke,[5]	123	34	273	-	22	-	156	-
Hudson,	7	4	32	2	-	-	-	-
Hull,	1	-	15	-	-	-	-	-
Hyde Park,	11[4]	3	25	-	23	4	11	-
Ipswich,	20	2	22	1	9	1	3	-
Lancaster,	-	-	2	-	-	-	1	-
Lawrence,	81	19	321	48	172	45	-	1
Lexington,	-	-	3	-	2	-	-	-

[1] Also an epidemic of rötheln in May, 1892. [2] Four cases of German measles.
[3] Four cases, character not specified. [4] Including membranous croup. [5] One case of small-pox.

Summary of Certain Infectious Diseases reported to Local Boards of Health — Concluded.

Cities and Towns.	Diphtheria.		Scarlet-fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Lowell,	69[1]	24	440	13	373	75	91	11
Lynn,	78	31	294	4	52	11	-	-
Marlborough,	2	-	200	4	-	3	3	-
Medford,	21	2	62	3	14	2	19	-
Melrose,	18	-	59	-	15	-	3	-
Milford,	3	4	60	-	-	2	-	-
Millbury,	5	-	32	-	15	-	2	-
Milton,	12[1]	2	5	2	2	-	16	-
Natick,	4	3	35	1	-	2	-	-
Needham,	2	2	8	-	-	2	14	-
New Bedford,[2]	63	8	188	2	74	17	-	-
North Adams,	86	15	79	8	23	12	13	-
Northampton,[3]	25	7	62	1	13	2	5	-
North Andover,	1	1	9	1	6	-	-	-
Orange,	7	2	1	-	20	-	2	-
Plymouth,	11	5	29	-	19	3	-	-
Quincy,[4]	22	10	54	2	26	6	31	-
Reading,	4	1	14	1	5	1	4	-
Revere,	8	2	34	1	4	2	7	-
Rockland,	1	-	9	1	15	6	4	-
Salem,	27	1	119	2	80	9	-	-
Saugus,	2	-	23	-	-	-	-	-
Somerville,	39	8	371	14	74	11	-	-
Springfield,	110	54	124	14	79	39	20	6
Swampscott,	2	-	9	-	6	-	-	-
Taunton,	28	6	178	7	28	8	-	-
Waltham,[5]	8	-	254	10	47	4	-	-
Ware,	7	3	29	1	10	5	-	-
Watertown,	2	1	17	1	4	1	-	-
Westborough,	4	-	19	-	-	-	-	-
Westfield,	8	-	25	-	-	-	-	-
Williamstown,	4	-	8	1	4	-	-	-
Winchester,	10	5	59	4	4	1	-	-
Winthrop,	2	-	6	3	2	1	-	-
Worcester,	203	58	449	16	92	19	51	1
Woburn,	25	6	111	4	28	5	-	-
Total,	3,033	891	6,112	281	1,892	435	783	31

[1] Including membranous croup. [2] Fourteen cases of small-pox and 2 deaths.
[3] 4 cases of German measles. [4] One case of small pox. [5] One case of typhus fever.

Amesbury.

Complaints have been entered and action taken by the Board in one hundred and fifty cases; and about as many more were abated upon the suggestion of a member of the Board, making nearly three hundred cases abated during the year, as against eighty-two in 1890. In more than half of all the cases the lack of proper sewers was the chief difficulty to be overcome. The town needs sewers. It would be a matter of economy to have a full and complete system laid during the coming year. An unsanitary town must necessarily be an unhealthy town, and in view of the probable advent of Asiatic cholera into this country the coming spring, and the present prevalence of typhoid fever and diphtheria, which are both filth diseases, it would be wise to fully prepare in time for the worst. The Board deemed it necessary to provide better facilities for caring for contagious diseases at the hospital for such diseases on the town farm, hence an addition to the old building was made. While this report shows an increase over previous years, this excess is more apparent than real, and is largely due to the vigorous efforts of the Board to have all the cases properly reported, as required by law.

Attleborough.

Early in the spring regulations were adopted and made public; these have been willingly complied with, so there has been no occasion for friction or the enforcement of severe measures.

The town has been free from epidemics of all kinds. The few cases of contagious diseases that arose were investigated and cared for; the Board acting on the theory that prompt attention to each case, though isolated, was wiser than waiting until more cases should be reported, thus endeavoring to save Attleborough the experience of other towns. This vigilance on the part of the Board has stimulated the physicians to promptly report their cases, and has aroused a popular sentiment that has approved and supported the measures adopted.

Belmont.

There have been four houses fumigated by the Board at the town's expense, as the occupants could not afford to pay for the same. Thirteen houses were fumigated by the occupants satisfactory to the agent of the Board.

Six complaints were made, which were investigated, and the nuisances abated.

Seven piggeries were inspected. The Board voted not to grant any licenses for the keeping of swine.

Beverly.

One of the difficult problems that confronts the Board at the present time is the disposal of garbage, the manner in which it has been collected

in the past being as much a nuisance as the garbage itself. The Board therefore recommend that some action on the part of the town be taken at its annual town meeting, relative to the care of this material, which the Board believes to be a great source of danger to the public health.

Boston.

At the commencement of the year influenza was prevalent, and the deaths from this cause contributed largely to the increase of mortality, so that at the end of January the excess of deaths over those of the same period of the previous year was 296, and at the end of the first three months of the year the deaths were increased by 556, largely due to this cause. The total number of deaths for the year was 11,236. The death-rate per one thousand inhabitants is found to be 23.92. This rate is .9 per thousand over the preceding year, and .5 per thousand over the average of the ten preceding years. The deaths from zymotic diseases show also an increase. This was especially the case in the mortality from diphtheria and scarlet-fever, while the deaths from typhoid fever and measles show a decrease.

The number of contagious diseases reported to the Board of Health for the year 1892 was 6,619, against 5,712 in 1891. The total number of deaths from the same diseases in 1892 was 832, against 471 in 1891. Measles has been quite prevalent. There were 1,563 cases reported and 19 deaths in 1892, as compared with 2,588 reported cases and 21 deaths in 1891. Typhoid fever was reported in 765 cases, and there were 137 deaths, against 966 cases and 154 deaths in 1891. There were 1,353 cases of diphtheria reported with 414 deaths, as compared with 833 cases and 232 deaths in 1891. Although there has been an increase in the prevalence of scarlet-fever this year, the disease has not been of an exceptionally severe type. The number of cases reported during the year has been 2,938 with 262 deaths, as compared with 1,327 cases and 64 deaths in 1891. It is frequently said that scarlet-fever is now much more prevalent than formerly; but a careful study of mortality statistics for the past forty-six years proves that this disease is diminishing in frequency and in severity. The difficulties of dealing with a disease like scarlet-fever are very great. The number of mild cases unrecognized and unreported in the community, and the length of time required for the process of desquamation, render the work of stamping out the disease impossible.

Since 1870 there has been a marked diminution in the number of deaths from consumption in this city.

Quarantine Station.

Valuable additions have been made to the facilities and accommodations at Gallop's Island. The method of giving baths has been made easier by a new building 87 feet long by 20½ feet in width, containing twenty-eight

bath tubs supplied with hot and cold water. Two new buildings, each 100 feet long by $30\frac{1}{2}$ feet in width, have been erected and fitted for dormitory uses, and they will each accommodate one hundred persons. To the old wooden chamber which has been in use for eight years for disinfecting by steam, there has been added a new building with an iron cylinder 20 feet long and $6\frac{2}{3}$ feet in diameter, properly fitted up for disinfecting by steam.

Precautions against Cholera.

In September, owing to the fact that cholera had appeared at quarantine in New York, it was deemed advisable to erect a temporary hospital at the South End for the treatment of this disease should it appear in this city. For this purpose land was taken on Swett Street, for the erection of a permanent hospital, and also for the erection of a permanent steam disinfecting apparatus. The permanent hospital, which is to be used not only for cases of cholera but also for the treatment of typhus fever cases, is a one-story building 100 feet long by 35 feet wide. There are accommodations in this building for about forty patients. It is divided into one large male and one large female ward, and four isolating rooms. It is heated by steam, lighted by gas and supplied with hot and cold water. The drainage from the hospital enters a pot-trap, so that it can be thoroughly disinfected before it enters the sewer. A special sewer 600 feet long has also been built The distance of this building from the street is about 100 feet. Particular attention has been paid to the ventilation. The beds are woven-wire springs and hair mattresses. The interior construction of the building is such that it can be very easily and quickly disinfected.

Glanders.

There have been eight cases of glanders in horses, all of which were immediately reported to the Cattle Commissioners, and the horses were subsequently killed.

Typhoid Fever.

The death-rate from typhoid fever for 1892, 2.9, is lower than that for any year since 1846. If the rate for the semi-decade from 1885 to 1889 is compared with that for the three years from 1890 to 1892 inclusive, it will be seen that there has been a marked diminution, the rate of the former period being 4.1, while that of the latter is 3 2. This marked diminution in the frequency of the disease may be fairly attributed to the improved water supply and also to better hygienic conditions From 1846 to 1849 the death-rate per 10,000 of the living from this cause was 17.4; after the introduction of the Cochituate water the rate began to decline, and it has gradually diminished to 3.2, the average for the past three years. This rate is lower than that of any of the larger cities in this country, and compares very favorably with the rates of foreign cities.

Disinfection.

In cases where contagious diseases have been reported, disinfection of the houses or rooms where the disease existed has been performed without expense to the occupants. School-houses and other places where contagion was suspected have also received similar attention.

Steam Disinfecting Station.

It has hitherto been the practice of this department to disinfect all movable personal effects in houses where contagious diseases have occurred, the work being done on the premises by a disinfecting corps attached to this department. During the past year a radical change has been made in the methods of performing this work by the establishment of a steam disinfecting station, to which all infected articles are moved in especially contrived vans for disinfection by superheated steam. The disinfecting plant is in a building adjoining, but entirely apart from, the cholera hospital on Swett Street.

The apparatus for disinfection is an iron cylinder 20 feet long, 7 feet in diameter, with a capacity of about 692 cubic feet, fitted with the necessary steam-pipes, gauges and valves. The outer shell is made of steel five-eighths of an inch thick; the inner shell is of galvanized iron one-eighth of an inch in thickness; a coil of perforated steam-pipes is placed at the top of the cylinder, the coil at the bottom is not perforated. The cars, in which the articles to be disinfected are placed, run on tracks into the cylinder, entering at one end and being removed at the other. There is no communication between the chamber where the disinfected articles are received and that from which the disinfected articles are removed. The boiler-house and disinfecting apparatus occupy about three-fourths of the building.

Two vans especially constructed for the purpose have been procured, one for the conveyance of infected articles, the other for the conveyance of disinfected articles. These vans are air-tight, so that there can be no danger of contamination to the public by their passage through the street. They are also built so that after the removal of infected articles they can be thoroughly disinfected.

Medical Inspection of Schools.

The need for beginning this work is made more and more evident each year by the presence of children in the school-room whose continuance there is an injury to themselves and a source of danger to others. It is also to be noted that the health of the school children is continually endangered by returning convalescents from contagious diseases with unwarrantable certificates of recovery. We therefore hope that the time is not far distant when the Board will be able to secure the necessary appropriation for this important work.

Public Baths.

Numbers of baths taken at the Public Baths during the bathing season : —

	1891.	1892.
Total men and boys, ...	836,086	908,889
Total women and girls, ...	178,702	216,947
Total of both sexes, ...	1,014,788	1,125,836

There have been 3,909 persons vaccinated, and certificates of vaccination have been given to 2,967 children for their admission to the public schools. In the only instance during the year in which small-pox was found to exist, all persons in the immediate vicinity exposed to the disease were vaccinated.

The bodies of 557 persons dying without a physician in attendance have been examined.

Infectious Diseases.

Fifty-two cases of eruptive disease reported as small-pox have been examined. Of these, one case was found to be small-pox, and the patient, a young woman who had been in the country only three days, was removed to the small-pox hospital on Canterbury Street, where she recovered.

Six cases of reported typhus fever have been examined, but in each instance the disease was found to be typhoid fever.

The names of 188 immigrants arriving in Boston from New York on typhus fever and cholera infected ships have been received from the State Board of Health, and an attempt has been made to discover the residences of these persons. In the majority of instances, these individuals could not be found. Whenever one of these immigrants was found, he was placed under careful medical supervision for a reasonable time.

An examination has been made of four reported cases of Asiatic cholera. In no instance, however, was the disease found to exist.

Abattoir.

There has been an unusual increase in the number of cases of actinomycosis among the animals brought for slaughter. This has occurred, undoubtedly, from the fact that in many of the Western cities where large numbers of cattle are slaughtered, animals affected with this trouble are ruled out as unfit for food. It has been our custom here to regard this affection as having only a local influence upon the meat of the animal during its early his-

tory, and to condemn only the part affected, so long as it remained purely local and the animal was otherwise in good condition.

Investigations are now going on with a view to determine whether or not the meat of such an animal should be regarded as unfit for human food. At present, however, we know of no facts by which we should be warranted in a general condemnation of such meat.

The act of the Legislature of 1892, requiring an examination of all animals, at the railroad yards, intended for exportation, together with the examination of all milch cows within the city, as required by the new regulations of this Board, has made it necessary to appoint an additional inspector.

Dairies and Cow Stables.

Knowing the dangers to which our milk supply is exposed by careless methods of production and handling, and knowing that many of the so-called stables within the limits of our city were unfit for the purposes for which they were used, this Board made and published the following regulations in April, 1892: —

Regulation.

Whereas cow's milk is one of the most common and necessary articles of food, and is oftentimes seriously impaired in usefulness and rendered dangerous to health by the want of proper care in its production or subsequent treatment or handling, it is therefore

Ordered, That the following regulation be and is hereby adopted: —

SECTION 1. No person shall use any building as a stable for cows, unless it contains at least one thousand cubic feet of space for each animal, is well lighted and ventilated, has tight roof and floors, good drainage, a supply of pure water, and all other necessary means for maintaining the health and good condition of the cows, and has been approved by the board of health.

SECT. 2 Every person using any such building shall keep the same and the premises connected therewith, and all land used for pasturage of the cows, clean and free from filth.

SECT. 3. Every person keeping a milch cow shall permit it to be examined from time to time as to its freedom from disease, by a veterinarian designated by the board of health.

SECT. 4. No person having an infectious disease, or having recently been in contact with any such person, shall milk cows or handle cans, measures, or other vessels used for milk intended for sale, or in any way take part or assist in handling milk intended for sale, until all danger of communicating such disease to other persons shall have passed.

SECT. 5. No person shall sell or use for human food the milk of a diseased cow, or permit such milk to be mixed with other milk, nor, until it has been boiled, shall sell or use such milk or any mixture of such milk for food of swine or other animals.

These regulations were printed in convenient form, and sent to every person known to keep cows in the city.

Animals killed at Abattoir.

Cattle,	33,303
Calves,	48,012
Sheep,	462,533
Total,	543,848

Animals Condemned.

	Number.	Weight.
		Lbs.
Cows,	38	11,321
Oxen,	3	2,500
Steers,	10	9,169
Bulls,	7	7,434
Calves,	16	720
Sheep,	6	250
Parts of animals,	–	4,045
Total,	80	34,469

Tuberculosis.

The following table shows the percentage of tuberculosis among cattle killed with the intention of being used for food: —

Class of Animals.	Number received.	Tuberculosis.	Percentage.
Whole number of all kinds,	33,303	52	0.15
Cows from Eastern States,	1,843	50	2.71
Cows from Western States,	–	–	–
Cows from Massachusetts,	1,414	44	3.11
Steers from Western States,	–	–	–
Oxen from Eastern States,	–	2	–

The work of inspecting the stables used for cows was placed in charge of the veterinary inspector, who examined the 2,348 animals kept in the

city limits. Eight were pronounced suspicious. Post-mortem examination showed that five were tuberculous.

The question of the amount of air or breathing-space required for each animal met with considerable opposition, but only among those who were prejudiced from the fact that their own stable did not contain the necessary amount of space; the common argument is, that the cows will suffer from cold in a barn of the required size, and also that they used to keep far more in the same space where they now keep what they call a few.

It has been made a point, on meeting the owners of cows having the required amount of space, to inquire as to the condition of the cows in the winter time. In all cases the answer has been that the animals were comfortable and never cold, and that fresh air and plenty of it would do no harm. The opposition met with in all cases, in regard to this point, has been among those having poor and anything but weather-proof barns. One of the greatest sources of danger from a poorly ventilated small barn is the repeated use of the expired air. When an animal with a chronic contagious disease, as pulmonary tuberculosis, is present, such air becomes not only a foul air, but a foul air contaminated with expired air of a diseased animal, which air is in turn inhaled, and endangers the otherwise healthy animals.

All grades of places have been found, from a small shed, one side of which was formed by an earth bank, and made tight by piling up the refuse about the stable, up to the best accommodation possible for animals.

The following is a sample of one of the cow-stables inspected: A long, narrow, low-studded shed, forming two sides of a square, two walls of which were formed by the stone foundation of an adjoining building; very little light, and confined to one end only; behind the stalls was a drain made of old paving-stones, allowing the drainage to soak into the soil below, and very little running outside of the barn. The interior dimensions of the barn were as follows: average height, 6½ feet; length, 42 feet; width, 18 feet. On entering this barn, which happened to be after it had been closed for some time, the odor was enough to stifle one. After reaching the inside, it was found to be occupied by seventeen cows and three horses. The present regulations would allow this barn to be occupied by only five animals.

Many places have been found where the cows seem to be used as so many milk machines, and their owners are not confined to those who are gaining their livelihood by the sale of milk.

Bradford.

Thirty-two notices have been sent property owners and tenants in the town, and in most cases the parties complied with the rules of the Board. In three cases it was found necessary to serve a second notice through the constable, and at the present time those three cases remain unsettled, awaiting the action of the town.

Two horses affected with glanders were killed and disposed of, during the year, in accordance with the direction of the State Cattle Commissioners.

One hundred and one buildings have been inspected by the inspector of plumbing.

Bridgewater.

About the middle of January a case of scarlet-fever occurred in a family living on Oak Street. This case originated in a neighboring town, where some of the family were employed. One after another of the children were stricken with the disease, until there were eight sick ones in the house. The mother, worn out with the care of the sick, was herself prostrated, and it was found necessary to obtain help. The chairman of the selectmen obtained two trained nurses from Boston, who immediately took charge of the family. The house was small, the family large, consequently the physician and the nurses had a hard fight, but won at last, and the disease was eradicated. A strict quarantine was maintained, and no contagion occurred except in the case of one person, who recklessly visited there during the earlier stages of the disease. This person was a domestic. On January 23 she began to show symptoms of scarlet-fever, and, not to endanger the children in the family, she was promptly removed by the chairman of the selectmen to the almshouse, for want of a better place. Here the niece of the matron, from being allowed to come in contact with the sick one too soon, contracted the disease. It spread no further, however, and we felt confident that the disease was under control; but about February 22 two cases broke out in families remote from each other, and having no connection with former cases. Two cases also occurred among the normal students who had but recently returned to the school. These cases were all quarantined, and no contagion occurred, except possibly one case at the normal boarding hall. Still the disease continued to break out in new places remote from those where it was known to exist, and among families who had no social intercourse. No case as yet had any connection with the schools. Finally, May 19, a child was taken sick in one of the lower grades of the model school. The school was immediately closed, with the exception of the higher grade, and the rooms thoroughly fumigated. On June 9, at the request of the school committee, the Board consented to the opening of the schools the following Monday, with this restriction, that no children from families where the disease had occurred should be allowed to attend. The epidemic continued during the spring and early summer, baffling every effort of the Board to account for its spread. The disease was of a very mild type; only one death occurred, and that from exposure and a complication of diseases. The board had long suspected that there were light cases, unreported, where the affected child was allowed to mingle freely with other children, and thus spread the disease. At length one such case came to the knowledge of

the Board, and other cases were traced to this. We cannot impress too strongly upon the minds of parents, especially during the prevalence of any contagious disease, the importance of consulting the family physician whenever children are even slightly unwell, and ascertaining beyond a question the nature of the complaint.

Brockton.

The number of loads of cesspool matter removed by the excavator wagon the past year was 1,980; the number of loads of night soil removed was 3,479; the number of loads of ashes removed was 4,933.

A lot of land has been purchased by the city, to be used as a dump for the southern portion of the city.

The city has purchased the right of flowage of the Salisbury River, which practically is the key to the draining of a larger portion of the city. This, with the surface drains already built, is a long step toward a perfect system of surface drainage for the city.

Brookline.

This year, as for several years past, the town has been free from small-pox. The law as to vaccination is enforced, and all persons who state they are unable to pay for vaccination for themselves or children have it provided free by applying to the Board, which also furnishes physicians convenient blanks for vaccination certificates and for reporting contagious diseases. The little emergency hospital for such contagious diseases as small-pox and typhus fever is in good condition, and ready for occupancy at a few hours' notice.

Scarlet-fever is still prevalent in Boston, and, by reason of our nearness and frequent visits for business and other purposes to the city, together with the fact that the great majority of the children here have never had the disease, and are therefore susceptible to it when exposed, it will not be surprising if we have a number of cases of it during the coming year. It is possible, however, with the conscientious and intelligent co-operation of all families having cases now and in the future, to improve on the record of the year just past.

An order was passed requiring children ill with whooping-cough to stay out of school.

It being found that during the hot months a large number of deaths result from gastro-intestinal diseases in bottle-fed infants and young children, the Board prepared a little circular giving plain directions for making milk safe by "pasteurizing" it, a better procedure than sterilizing it, and early in the summer distributed copies of it among families in those parts of the town most likely to suffer. It is gratifying to find that, even with the very hot weather of last summer and with an increased population, there was a decided decrease in deaths from the disorders mentioned.

In the latter part of September there was received a numerously signed petition from residents in the neighborhood of Holyhood Cemetery, near the Newton line, asking that steps be taken to abate the prevalence of intermittent fever there. The Board viewed the lands in question, gave a hearing October 6, and had a survey made; and it is believed the necessary data will soon be at hand for successfully draining the stagnant ponds and rotten land in that otherwise healthy region. The fact that the co-operation of the city of Newton will be necessary will of course delay somewhat the progress of the work, and it is probable that some time must elapse after the proposed drainage or any other suitable measure is in operation before a decided decrease in the amount of malaria there can be expected.

The public swimming bath and the portion of the brook above it were duly inspected and cleaned out early in the summer. Though the analysis of the water, the absence of accidents and the number of baths taken (over seven thousand the past season), show the swimming bath is both safe and popular, the introduction of a still purer water supply by such means as the superintendent of water works may advise, the building of a considerably larger tank or reservoir and the employment of an instructor in swimming, would materially increase the number of patrons and its usefulness.

Canton.

Canton has been free from the ravages of serious epidemics. We have had less of typhoid fever, diphtheria, pneumonia and measles than in former years. In April and May, 1892, there were reported four cases of scarlet-fever and fifty of scarlatinoid roseola; in November, three of scarlatinoid roseola. The only epidemic we have to report is that of German measles, when neither measles or scarlet-fever were prevailing in town.

Wells from which parties continue to draw water are every moment in danger of becoming polluted, and need constant watching. Let us look for a moment at the situation of many of these wells: we find many of them from ten to fifty feet from an ill-constructed and poorly kept privy vault; sink drains passing near them; the fatal back-door slops are poured by them every day. All this may have been going on for years, and still the well holds good; but how much longer it will continue no one can tell. When too late they may awaken to the fact that it has become polluted, but it may not be until some loved one has passed away. We would suggest to every one having a well thus situated not to wait until contamination has taken place, but introduce town water at once.

Chelsea.

We are of the opinion that physicians have not been particular in reporting all the cases of typhoid fever that have come under their treatment.

Nuisances abated, 1,206. Three hundred and four permits for plumbing have been issued during the year. All the privy vaults in the city have

been examined during the year; the total number of vaults within the limits of the city is 944. The privy nuisance is one of the most perplexing that the Board has to deal with. The work of removing night soil is done by the Odorless Excavating Company of Boston, under a three years' contract, which will expire April 30, 1893. The work has been done in a satisfactory manner.

Chicopee.

Early in the winter the unusual prevalence of typhoid fever at the Falls led the Board to suspect our source of domestic water supply as the cause. Communicating with the State Board of Health, they sent their agent to our city, and some time was spent in investigating this matter. The prevalence of typhoid at Indian Orchard and Ludlow, in the fall and early winter, was established, and several cases investigated, to see whether the dejecta of the patients was destroyed or allowed to find its way through the sewers into the river. The latter was found, in almost every instance, to be the case, and, as the germs of typhoid may preserve their vitality for a long time in water, there is little doubt of its origin and propagation in our own experience. A circular was issued and left at every house, warning the people of the danger incurred in using the water, and directing it to be boiled before drinking. How far this warning has been heeded we are unable to state, but the disease has disappeared as an epidemic in this part of the city.

Concord.

With the exception of pneumonia and influenza in the early part of the year, and the more recent epidemic of measles, there has not been an unusual amount of sickness during the past year. About the middle of December measles broke out among the children, caused, very likely, by a single mild case which was not recognized by the parents of the child, who was allowed to attend school while affected by the disease, no physician being consulted. From this cause, doubtless, all the trouble and discomfort inflicted on so many of our children and their parents arose and spread, until it seemed as though a majority of families in town had one or more cases. Fortunately, the disease was of a mild type in most cases, and no fatalities occurred. Up to January 1 sixty-nine cases had been reported, and from that date to March 1, one hundred and eighty-nine more, making two hundred and fifty-eight cases of measles within ten weeks. Some of the schools had to be closed a week or more on account of it, and would, probably, have had to remain closed for a much longer time, had not the Board, at the suggestion of the school committee and the superintendent of schools, suspended for two months Regulation No. 23, requiring that "No scholar shall attend school while any member of the household to which such scholar belongs is sick with measles, or thereafter without a permit from the Board." We believe our action in this matter was very generally approved

and that no evil resulted, while the schools were enabled to continue their work with an immediate largely increased attendance. From this experience parents should learn the importance of immediately calling a physician when their children are ailing, to ascertain just what the nature of the disease is. In any event this is the wisest course to pursue, rather than take a risk that in the end may result in a good deal of expense and possibly the loss of some of their children.

In September last several gentlemen, by invitation, met together informally to consider the subject of the pollution of our rivers and brooks by sewage. A good deal of interest was manifested, resulting in the request to the Board of Health that a public hearing be given before them for the purpose of discussion and a fuller consideration of the subject. The subject was clearly and forcibly presented in its various phases, several gentlemen taking part in the discussion which followed. As a result, the sense of the meeting was in favor of a request to the Board of Health that they should make a regulation, in addition to those now in force, "forbidding the discharge of the contents of any privy, sink, cesspool or other sewage or filth, either directly or by overflow, into the rivers, or into brooks or drains emptying into these."

Recapitulation of agent's report: —

Premises inspected,	766
Waste pipes needing traps,	9
Traps found to be defective,	9
Number of places without traps,	206
Cesspools cleaned,	37
Cesspools found to be defective,	5
Vaults cleaned,	115
Drain pipes found to be defective,	13

Instead of requiring the lapse of four weeks after recovery from an infectious disease before fumigation, as heretofore, it is now left to the judgment of the attending physician to say when it may be done with safety.

Cottage City.

The agent has inspected ninety-one cases of nuisances, and has served fifty-three notices for abatement of the same. From June 1 to November 1, during which time our population is increased many times by the influx of summer visitors, we issued one hundred and thirty-eight permits for removing the contents of cesspools, sixty-two permits for removing the contents of privy vaults and twenty-eight permits to gather and transport swill.

The health of our town and freedom from any epidemic of infectious and contagious diseases during the past year is a matter of sincere congratulation.

Dedham.

The Board earnestly recommend that the incoming Board of Health for 1893 be instructed and authorized to confer with the Hyde Park Board of Health and the city of Boston relative to the necessary steps for the sewerage and drainage of Dedham, so that this matter may be placed on a suitable basis for future action. It would also be advisable to empower the Board to make the necessary investigations, ascertain the expense of a sewerage system and present its results to the town. Such a step will force itself upon the town at no distant date. In considering this matter of sewerage, it may be extremely pertinent to present the question of the jail sewerage and county buildings in Dedham. The establishment of a system of sewerage for the entire town would at once obviate any difficulty that might arise in this respect, since the jail sewage would be disposed of in common with the rest of the town sewage.

East Bridgewater.

There were several cases of scarlet-fever in town which were reported to us. In all cases visits were made and patients caused to be isolated during illness, and upon recovery the premises were fumigated and disinfected. In two of the cases we were obliged to require the heads of the families to remain away from their work, and at home, for a period of two weeks, believing that there was danger of spreading the disease by allowing them to go from their homes to mingle with their fellow-workmen. In both of these cases our action undoubtedly was a source of hardship to the men, for they rely for the support of their families upon their daily earnings. Chapter 80, section 40, of the Public Statutes, provides that in cases of sickness from epidemic diseases, "the Board shall make effectual provision, in the manner which it judges best, for the safety of the inhabitants, by removing such person to a separate house or otherwise, and by providing nurses and other assistance and necessaries, which shall be at the charge of the person himself, his parent or master, if able, otherwise at the charge of the town to which he belongs," etc. Under this provision we thought we had power to render these men assistance, because, while not paupers, or in any way subject to any action of the town under the poor laws, we deemed them persons not able to bear the expense of nurses and other things necessary to be furnished at such times and in such emergencies, in addition to the loss of earnings. We therefore undertook to render them some assistance, and to compensate them for their loss of time, considering that their earnings were lost by reason of an imperative order from town authority, given for the benefit of the people of the town. We had them make out bills for their time lost. These bills the selectmen declined to pay, unless the men would make application for aid under the poor laws. The Board of Health were, perhaps, technically at fault in having these

bills made out as for time lost, instead of as for "nursing and attendance," and treated the expression "other assistance" in the statute too broadly. We believed, however, and still believe, that the powers of boards of health are based upon the idea of the general good and safety of the people of the town at large, and not on the fact that individuals may from time to time be in distress. In cases of epidemics their powers are more nearly analagous to those of fire engineers than to overseers of the poor. In cases of conflagration, fire engineers may demolish buildings in order to arrest or prevent the spreading of fire, and the owners of the buildings demolished may recover reasonable compensation of the town for the buildings demolished; the idea being that the community shall contribute to the expense of preventing a general disaster, and not have the property of one taken for the benefit of all without some compensation. One who demanded compensation for the destruction of his house would not be called a pauper, or be told that he must apply for relief under the poor laws. We took the men's time for the general benefit, and made them stay at home and take care of their families, not because the men were sick or in need of relief, but in order to prevent the spreading of contagion in the community. We do not, and did not, consider them paupers because they could not bear the loss of their earning time, any more than we should consider that man a pauper who could not bear the loss of the destruction of his house.

Everett.

Three hundred and eighty-one nuisances and complaints have been investigated during the past year, about two-thirds of which were caused by overflowing cesspools and the non-collection of swill.

Cards have been put up and records kept in one hundred and thirty-five cases of contagious diseases.

Fall River.

During the small-pox and typhus fever scare, communications were received from time to time from the State Board of Health, accompanied with the names of emigrants from ships and ports infected with those diseases, whose destination was Fall River. Such emigrants were promptly, though with considerable trouble, located and placed under surveillance.

During the prevalence of the Asiatic cholera at quarantine in New York every precaution deemed necessary was taken here; upon applications the city council empowered the board of overseers of the poor to provide this Board with hospital accommodations, if occasion should arise for them. Seven assistant sanitary inspectors were appointed, and a house-to-house inspection was made, which resulted in a thorough cleaning of the city; two port physicians were appointed, who met every incoming train and steamboat; a rigid watch was kept upon all incoming passengers, and

their baggage and everything of a suspicious character was thoroughly investigated; and happily we have no case to record. We cannot dismiss this subject without calling attention to the city's entire lack of hospital accommodations, in case we should be unfortunate enough to have a visitation of either small-pox, typhus fever or Asiatic cholera; and we would urgently impress upon the city council the necessity of losing no time in making suitable provision. We would suggest that such a building be so constructed as to have a public disinfecting station attached thereto.

The collection and disposal of all refuse coming under this head, separate and apart from ashes, is a subject which we recommend to the serious consideration of the city government. Many cities are provided with crematories in which such waste is destroyed by fire; and we respectfully submit that it might be worthy of the attention of the city council to investigate their workings, with a view to introducing the system here.

Number of complaints received and investigated, 1,318.

There were 1,326 persons successfully vaccinated under the supervision of the city physician at the city dispensary during the year; this was an increase of 320 over the preceding year. Arrangements are made whereby all who desire can be vaccinated free of expense.

Fitchburg.

The disposal of garbage is a subject of discussion in many cities, and only one satisfactory way has been found for its disposal, and that is to destroy it by fire. It is hoped by us that the city at its earliest convenience will build a furnace in a suitable locality for the cremation not only of garbage but dead animals.

The report to the Board of Health of the inspector of animals states that so far in his examination he has found forty head of cattle that are suspected to have tuberculosis. They have been isolated and are now under observation. Four were ordered killed, three of which on post-mortem examination proved to be diseased with tuberculosis. The carcasses were properly disposed of, and not allowed to be sold for food.

Framingham.

In November an epidemic of scarlet-fever started at South Framingham. This outbreak could be traced to an imported case. The schools of South Framingham were closed. The Board of Health took action to secure an emergency hospital, where cases of disease dangerous to the public health could be isolated and properly cared for.

Two hundred and twenty-two tenements and seven business blocks have been connected with the public sewer during the year.

The death-rate for the year 1892 was 16.6 per 1,000 inhabitants.

Gardner.

During the present year the selectmen appointed a board of cattle inspectors, to work in connection with the Board of Health. Since their appointment they have examined three hundred and forty-six cows, comprising thirty herds. Of this number, two have been condemned and killed.

In the early spring there was an extensive epidemic of scarlet-fever, which had its beginning in the year before; but its character was of so mild a type, and so successfully treated, that not one death occurred in fifty cases. Deserving of more than passing notice is the fact that during the past two years there have been reported to the Board nearly a hundred cases of scarlet-fever, and not a single death from this dread disease.

There have been fewer cases of diphtheria this year than last, but the death-rate a little greater. During the last two or three months there has been an extensive epidemic of measles, but no death resulting except from complications.

Gloucester.

The number of nuisances requiring the attention of the Board of Health was two hundred and ninety-two. We are especially favored in the matter of fine beaches, and during the summer our own people and visitors resort to them in large numbers for bathing and recreation. The Board of Health inspected them previous to the anniversary exercises last summer, and removed considerable filth from them. Any person who deposits filth upon a beach commits an act which is prejudicial to our interests as a summer resort. Nature has so wonderfully endowed our city in the way of beautiful scenery, that we should not spoil the effect by collections of material objectionable to the eye.

The condition of the region on and bordering Burnham's Field and Harbor Swamp became such in the summer that an effort was made to secure better drainage by removing obstructions from the brook which courses through these fields. The Board of Health personally superintended this work, and when finished, a notable improvement was manifest.

The question of the disposal of night soil is more serious than ever before. By hook or by crook the contents of the vaults have been disposed of; objections have been made by those near the places used as dumps, and a discontinuance of the practice ordered in one or two instances. There are four methods by which this material may be gotten rid of: the first, by dumping on land; the second, by dumping in the ocean by means of a scow; the third, by cremating it by means of one of the well-known processes, as the Engle, the Simonin and others; the fourth, by building a sewerage system. As to these methods, the dumping on land accommodates many by the discomfort of others; the scow is very cheap, and could probably be rendered available here; the cremating process for night soil could hardly be given intelligent discussion just now,

and cremation finds its largest use in the disposal of garbage; sewerage would drain the central and thickly settled parts of our community, and of course would do that well, and it is probably only a question of time when sewerage will be introduced here. Garbage: if a scow is of advantage for this purpose, then there is no place on the coast so favorably situated for using it as our city. Certainly the cheapness of the method and probable reduction in price per load for removing vault contents would commend it.

It is probable that nothing could be of so much benefit as a small hospital for contagious diseases, where children could be taken as soon as their diseases were announced, and carefully treated. This would prevent the rest of the family from getting the disease, and would allow those who would otherwise be prevented from working or attending school, to attend to their duties.

Great Barrington.

The number of cases of scarlet-fever recorded during the past year would indicate more danger from that disease than has really been present; the cases have usually been of a mild type. One of the schools in the north part of this village was closed for two weeks during the winter, owing to the presence of this contagion in the neighborhood; but the disease was suppressed, and at this time not a single case exists in the town. We have enjoyed perfect immunity from diphtheria, not a case having been reported during the year. Typhoid fever has also been entirely absent; as far as the health officer knows, not a case has occurred in the town.

The keeping of swine in the villages is wrong, and should be discouraged if not positively prohibited.

Greenfield.

Most of the complaints made to the Board of Health during the past four years have been with reference to bad plumbing and drainage. The crying need of Greenfield to-day is a proper system of sewerage. The Board recommends that steps be immediately taken to have an accurate map made of all sewers, drains, water pipes and gas pipes in the town, and that steps be then taken to construct sewers that will be ample in capacity for both sewage and surface water.

Haverhill.

During the year two hundred and eighty-three privy vaults have been removed, and since January, 1888, the number abolished is eight hundred and sixty.

Four hundred and seventy-six jobs of plumbing have been inspected by the agent, and have averaged three visits to each job of work, making a total of 1,428 inspections.

The question of sewers lies at the very foundation of the city's sanitary system, and negligence or errors will certainly be followed by disastrous consequences. It is to be regretted that sewers do not precede the construction of dwellings in the newly built sections of the city.

We would again urge the importance of making some provision for the treatment of persons afflicted with dangerous, contagious or infectious diseases Many times, if we had possessed the proper accommodations, cases of diphtheria and scarlet-fever would have been removed from their poor surroundings to where they could receive care and treatment that were impossible in some of the homes and boarding-houses. The old pest-house has been torn down, and the city is to-day without even a place of any kind for reception of small-pox patients. By good fortune the city has been spared the necessity of its use for several years; but with New York City now infected with typhus fever, which may succeed in obtaining a foothold in the New England cities, and the approaching danger from cholera next summer, it is the part of prudence not to wait for the emergency, which may arise at any time. It is to be hoped that the present city council will see the necessity for an isolation hospital, of an inexpensive character, which could be used not only in the emergency of epidemic visitations of small-pox and cholera, but for the treatment and restriction of diseases like diphtheria and scarlet-fever. This is the second or third time that we have asked the city council to establish a hospital for patients suffering from contagious or infectious diseases who cannot be properly isolated at their homes.

Holyoke.

An attempt has been made during the past year to compel the property owners to supply separate receptacles for ashes and house offal, according to the rules and regulations of the Board of Health. A man appointed especially to do that work waited upon all the property owners, in order to persuade them to observe that rule. The response to his request has not been as prompt or as universal as the Board would desire. During the coming year the Board will insist on the observance of that rule. Its observance will render the work necessary for the collection of ashes much less, and greatly improve the general appearance of our alleys.

Again, this year, we were visited by small-pox. This case occurred in a crowded tenement district, and it was a providential circumstance that we were spared an epidemic of the scourge. This patient, as usual, worked in the rag-room. The patient was removed to the pest-house, and the inmates of the block were subjected to a strict quarantine for ten days, in order to see if any other case would arise. All persons who had come in contact with the patient were immediately vaccinated.

During the early part of the year diphtheria prevailed only to a slight extent. However, during August, a very malignant type of the disease

appeared in South Holyoke. It persistently clung to that locality during the subsequent two months.

One of the great needs of this department is a sanitary inspector, an official whose duty it will be to look after contagious diseases, find out, if possible, why the disease arose, look over the plumbing, and prevent people from spreading it by compelling them to observe the rules and regulations of the Board of Health. This matter has been referred to in previous reports. It presented itself so forcibly to the present Board by reason of the great prevalence of contagious diseases this year that it was decided to employ a reliable man next year for such work. During the year the Board caused cards to be displayed on all houses in which there was scarlet-fever or diphtheria. But as long as the well children in the infected family are allowed to play and associate with all in the neighborhood, such an attempt to limit a disease is abortive.

Although the present exclusion of foreign rags handicaps one of the chief industries of our city, yet the general public safety depends upon it. No rags collected or shipped from a suspected country or port will be allowed to come into the city under any conditions.

Hudson.

There has been no serious epidemic, and the general health of the town has been excellent. The good care taken as to sanitary matters and disposal of drainage has no doubt contributed to this desirable condition.

Hull.

In regard to the Bradley Fertilizer Company of Weymouth, there have been some verbal complaints about the odor from the works when the wind is from that direction; it is well for the town to appoint a committee each year to look after this matter.

The Board requests all persons owning or leasing houses where there is a public sewer to have them properly connected with the same.

Ipswich.

The number of deaths in 1892 was one hundred and two. Infectious diseases have been for the most part in a mild form. It was decided to place placards on all houses where there were cases of scarlet-fever or diphtheria, and at the same time to leave printed precautionary directions, while especial care was taken that these diseases did not spread to neighborhood dwellings. This has been accomplished, and in no case have either of these diseases extended beyond the house in which it originated or to which it was brought.

It is our duty to call the attention of parents and officials to the fact that owing to the comparative freedom from small-pox for a number of years

there has been almost complete neglect of vaccination, and that probably one-half of the children now enrolled as pupils in the public schools have never been vaccinated.

Lancaster.

The town has been exceptionally free from epidemic and contagious diseases during the year.

Glanders, farcy and tuberculosis prevailed to some extent among the cattle last year, but seems to have been thoroughly stamped out, no cases having been reported during the current year.

Lawrence.

The custom of selling the swill to be fed to animals should be stopped, as it is unwholesome, and not suitable as food for any animal. It is hoped that a crematory will be erected during the year, in order that the swill, as well as other injurious waste matter, may be disposed of without endangering the lives of the people.

During the year 15,338 loads of ashes and rubbish have been removed, and 427 loads of paper. In the spring a wagon was built for the purpose of removing paper and other light rubbish. This team has been a great saving in time, as it holds three times as much as an ash cart. It is also used to remove infected bedding and refuse from the markets. In this city we are burdened with three great evils which have to be contended with in combating disease, especially contagious diseases, viz.: no suitable way to dispose of the waste matter; want of sewers in some sections; impure water. When the filtering gallery is finished, the latter cause should no longer trouble us.

The Water Street sewer, in process of construction, will benefit that section of the city where there is the greatest necessity for it; and if the crematory is provided the city will be in excellent sanitary condition, with the exception of the necessity of sewers in some sections of wards 1 and 6.

On account of the spread of scarlet-fever, which the Board considered was chiefly caused by non-observance of the regulations, it was thought best to detail two men to watch the premises where contagion existed, one man watching during the day and the other at night. This plan was continued for three weeks, at the end of which time the marked decrease in the number of new cases demonstrated the wisdom of it.

Lexington.

The Board has been obliged to be very peremptory in some of its notices, particularly in regard to unsanitary wells. Now, to intimate that your neighbor's well is in an unsanitary condition is an unpardonable offence; this domestic sensitiveness is universal, and the more truthful the accusation the greater the offence. An unsanitary water supply is a dis-

grace and a danger, — a disgrace because preventable, a danger because it may produce sickness and death.

There are a great number of privies in town which are poorly constructed and dangerous; every privy should have a water-tight vault, or, better still, a portable box, in which every day should be placed a small quantity of dry earth.

People should have more confidence in their ability to prevent rather than to cure disease, and exercise their common-sense toward improving the sanitary condition of their abiding places.

Lowell.

The Board has this year inspected every house, and ordered changes where it was deemed advisable. The only fault to remedy is the overcrowding of some of the tenements.

June 6, 1892, the mayor signed a resolution, passed by the city council, appropriating eight thousand dollars for the erection of the Engle cremator. The problem was to secure a place with railroad facilities, as near the geographical centre of the city as possible, in order to save time and reduce cost of teaming, and still not seriously inconvenience a thickly settled portion of the city, especially if there were a large number of homes near the proposed site.

The cremator was ready for trial December 14, and on that day the six days' test was commenced by Col. W. F. Morse, agent of the Engle Company, with the following result: —

Swill burned,	81.46 cubic yards, weighing	101,142 pounds.
Refuse burned,	23.01 cubic yards, weighing	3,787 pounds.
Total,	104.47 cubic yards, weighing	104,929 pounds.
Coal burned,		$10\frac{3}{4}$ tons.
City labor,		$12.00

No smoke or odor from the burning.

During the six days' test all the waste collected by the city was destroyed; but the cost was more than that which was stipulated, because of the fact that the collection included so small a proportion of refuse, and was almost entirely solid swill and water. There can be no doubt of the capacity of the cremator to destroy the specified amount (seventy cubic yards) within the specified time just as soon as the collection service is able to deliver it at the furnace, but there is doubt about the cost.

The report contains a special paper devoted to the subject of the garbage crematory.

We have connected with the Board of Health one inspector of plumbing, who is himself a practical plumber, and who has overlooked and inspected

during the year two hundred and eighty-seven different jobs of plumbing. He has had not a little trouble with some of the persons who do plumbing, it being necessary at times to visit and inspect this work every day. With some others engaged in the business he has had no trouble at all, the rules being lived up to in spirit at all times.

The work for the last year, outside of its routine duties, that most concerned the Board and the city of Lowell, was the endeavor to find out how many of the farmers who bought swill in Lowell were feeding it to cows instead of swine. As a result of this investigation, warrants were sworn out against seven persons, under chapter 326 of the Acts of 1889.

Since the time of the above trip the inspector has, from time to time, visited the milk farms in the adjoining towns, and while, as a rule, they were in very good sanitary condition, in some cases they were very bad; all, however, promised an improvement.

From July 2 to September 17 there were 23,265 baths taken by males alone.

Lynn.

The Board of Health submitted the following questions to the city government: —

First. How shall the house garbage, collected in this city, be disposed of without injury to the health of the people?

Second. What disposal shall be made of the night soil?

Third. What is the best method of disposing of the ashes collected?

Fourth. How can the Board of Health give better service to the city in collecting the house garbage and night soil with the limited accommodations for the stabling of horses and wagons?

A special committee of five members was appointed by the city government, and authorized to inspect such systems of disposal of house offal and garbage as they shall deem expedient, and reported in favor of the Simonin process. No action was taken upon the report of this special committee.

In March the Board made an investigation into the method adopted for the disposal of night soil by the city of Boston, and found that the night soil was taken out to sea and dumped. From this and other investigations the Board became satisfied that this plan was the only proper one at present, and steps were taken to ascertain the cost of a scow for that purpose. On Sept. 6, 1892, the city council appropriated the sum of $5,000, for the purpose of purchasing a scow to be used for the disposal of the city garbage, and for such other expenses as the sanitary needs of the city required, the expenditure to be made under the direction of the Board of Health. On September 12 the Board made a contract for the construction of a scow, to cost the sum of $2,100, and the scow was delivered Oct. 13, 1892. While the scow was in process of construction, the Board endeavored

to obtain a suitable wharf where the scow could be moored and loaded. Until the outfall sewer is constructed, or a permanent wharf for the scow is obtained, the scow is useless. We earnestly recommend that immediate steps be taken to construct the outfall sewer to deep water with a sufficient roadway on top, and a wharf at the end to enable the teams to drive on it and fill the scow.

No action of the city council having been taken upon the report of its special committee referred to above, and the great nuisance arising from the dumping of garbage still continuing, the Board decided to use the scow as a temporary expedient for the disposal of garbage. The Board, while believing that at present the best course to pursue with reference to the disposal of garbage, as a temporary expedient, is to tow it out to sea a distance of ten miles from shore, wishes to protest against such a method if it is to become permanent; for, if this and other cities adopt such a method, our shore will be sprinkled with this offal, destroying the beauty of our beaches and creating a cause of disease. We therefore recommend that the city council immediately adopt a system of cremation or extraction for the disposal of the garbage, and to adopt either the Engle crematory or the Simonin process for the disposal of garbage.

In May, 1892, the Board submitted to the city council a memorial praying for some action to provide an isolated ward or building for the care and treatment of contagious diseases, and suggested that some arrangement might be made with the hospital management for its location on their property, in order that the patients might receive the attention of the physicians and nurses connected with this institution. The Board was induced to take this action because a man had appeared at the police station with scarlet-fever, and it was discovered that Lynn had no resources for caring for him.

Marlborough.

During the past year there has been a large number of cases of scarlet-fever, with comparatively few deaths, and those not directly due to the severity of the disease itself. From the experience of the Board, it would seem to be a harder thing to control the spread of a non-fatal epidemic than one of a severer type. It has been hard to convince families where scarlet-fever has appeared of the necessity of controlling an epidemic of so slight severity.

The establishment of the office of inspector of plumbing and drainage, under the direction of the Board of Health, has been, and will continue to be, a great benefit, from a sanitary stand-point, to the inhabitants of Marlborough, for a sewer system without proper connections would be worse than none.

There have been several cases of tuberculosis, glanders and hog cholera during the past year, and the Cattle Commissioners have been duly notified and have made a personal examination, or advised the Board in each case.

The inspector of provisions has relieved the Board in a great measure of any anxiety as to diseased meat. He discovers the disease at the slaughter-house or at the market, and through the Board the Cattle Commissioners are notified of the herd where the disease exists.

Medford.

Three special sanitary inspectors were appointed Sept. 12, 1892. During their two months' service nearly the whole town was thoroughly inspected, including particularly those portions in which an epidemic disease like cholera would be more likely to gain a foothold. The cost of this special inspection was $624, and we are confident that the majority of our citizens will feel that the money was well expended. Our special inspectors visited 2,085 premises, and found 1,214 in good sanitary condition.

The question of disposal of swill and garbage is one of vast importance and vexation. Its use for food in piggeries is decidedly objectionable; it should be destroyed, but whether by fire or chemical agents is perhaps a question, which we sincerely hope the city will take steps to decide.

Melrose.

The almost constant presence of scarlet-fever or diphtheria, in greater or less degree, in our community, demands more caution respecting the spreading of these infectious diseases. It is hardly less than a crime for residents of an infected house to circulate through the public shops, and even, as in some instances reported, to go straight from the infected house to church and to public festivals. When either of these diseases occurs, those members of the family who must nurse the sick should plan to remain in the house till the sickness is over, and till danger of spreading the disease is past, as certified by the physician. But other members of the household, boarders and such, should, if possible, at once obtain a temporary home elsewhere, till all danger is over. If a letter written in a scarlet-fever chamber carries the germs of death to its destination hundreds of miles away, much more may a public library book scatter infectious disease throughout an entire community. Hereafter vigorous measures will therefore be employed to fumigate any books that may happen to be already in an infected household, and to prevent the passage of any books from the library to all such houses.

The Board has begun, with the current year, the publication in each of our newspapers of a monthly report, giving at the first of every month careful statistics of the contagious and other diseases, and of the mortality during the previous month. It is a matter of much interest to every intelligent person to be informed as to the general health of the community, and these trusty statements furnished by official authority tend to prevent exaggerated rumors of sickness and fatality.

Milford.

The local Board ordered a house inspection to be made. The result was very satisfactory, the recommendations of the Board having been in nearly all cases cheerfully complied with. The Board of Health would recommend such inspection to be made in the spring.

The Board has been called to unite with the other towns and cities on the Charles River in some comprehensive plan for the purification of the river, and has been present at all meetings of the committees.

It has become an imperative necessity for the town to take action in regard to the disposition of sewage, and it is hoped that the town will pass a law authorizing the Board to compel the removal of all privies and cesspools from the banks of the river.

Millbury.

During the year there have been many cases of contagious diseases, but happily a small mortality from them. It is worth remarking that the fifteen cases of typhoid fever all occurred within a few rods of the Blackstone River.

Milton.

The matter which has demanded more attention and time than any other is the keeping of swine as a trade or employment. No more than two swine were allowed to be kept without a special license.

Natick.

It is to be hoped that a sewer will be adopted soon, before the inhabitants suffer in a greater degree from the evils of cesspools and vaults.

Give us a plenty of pure drinking water, and let us have our streets and back lots in a perfect sanitary condition. These things will be found to be great promoters of temperance and prosperity.

The town was fortunate in escaping an epidemic of diphtheria, as three of these cases were in one family in a populous part of the town, and were all of a malignant nature. Strict quarantine and vigorous measures of disinfection confined the disease to this house.

Needham.

As in previous years, the matter of regulating the keeping of swine has been the most difficult problem to solve, and after repeated appeals to clean up their premises, it was found necessary in certain cases to resort to the court for enforcement of orders. Six suits were commenced against as many parties for keeping swine in violation of an order of the Board. One gave up the business before the suits came to trial. In the other five cases the court issued an injunction against the keeping of swine, and the use of the premises for that purpose on and after the first day of March, 1893. One other party, after repeated requests, has also given up the business, making a total of seven.

North Adams.

The Board has made twenty official tours of inspection. All nuisances of which complaints have been made have been inspected, and also a large number of others to which our attention was not in any way called except by our own examination. Total nuisances abated, 378.

In our opinion, the swill from dwellings ought to be collected the year round, instead of during the summer only. And also there should be the means at command to employ, on behalf of the Board, an inspector whenever needed, whose duty should be to hunt for nuisances and bring them to the attention of the Board, and to follow up the orders issued by the Board and report whether the orders have been obeyed, and to disinfect houses when necessary.

North Andover.

The Board had one thousand copies of the rules and regulations printed and distributed, also posted, as required by law. Fourteen houses were placarded. The agent fumigated all infected rooms in a thorough manner. No secondary cases occurred. All written complaints received by the Board have been investigated. Too much care cannot be exercised in preventing the spread of contagious and infectious diseases.

We earnestly recommend that the town construct a local sewerage system, and introduce a public system of pure water supply. For the present, an odorless wagon should be obtained, and a person employed to remove the contents of vaults and cesspools at the owners' expense. The report closes with an abstract from a paper urging upon the citizens the importance of introducing a public water supply.

Norwood.

Applications are very frequently made to the State Board of Health for the purpose of obtaining analyses of the water of private wells, but the Board has no special appropriation which can be applied to this purpose. Such analyses should be made at the expense of the owner of the well, or of the town in which he lives, and under the supervision of the local Board of Health, which also has the advantage of being on the ground, where it can make the necessary sanitary examination which should always accompany such analysis.

The local Board of Health of Norwood has very properly provided for such an emergency by adopting the following resolution: —

"Should any well, cistern or other receptacle, the water of which is used for drinking or culinary purposes, present a suspicious appearance from unsanitary surroundings, the Board of Health may make a single qualitative examination of the same; and should it be found to contain any sub-

stances which are likely to be hurtful, the Board may cause the water to be analyzed by a competent chemist, and by him pronounced safe, before allowing it to be used, and the expense incurred thereby shall be paid by the owner of said well."

Orange.

The Board has received one hundred and forty properly signed complaints, involving the investigation of two hundred and ten sources of offense, filth and pollution. In the routine of every-day professional labor, the members have individually looked into ninety-three more, making in all a grand total of over three hundred unsanitary conditions. Five times the Board has been compelled to resort to legal forces of acceleration. One case only was appealed, and necessitated attendance on court three days at Greenfield, but was then settled by the defendant.

Three houses have been condemned as unfit for habitation, and the tenants required to move. One slaughter-house has been abolished, four red flags and cards of warning have been displayed, seven carcasses of dead animals have been removed.

The unprecedented number of twenty cases of typhoid fever has been brought to the notice of this Board, and we are of the opinion that to no cause is it so directly traceable as to our insufficient and impure sources of water supply.

Plymouth.

Communications from time to time have been received from the State Board of Health notifying this Board of foreign arrivals in this country of parties whose destination was Plymouth, who had been in danger of typhus fever, small-pox or cholera. The Board, realizing the danger that might occur from such sources, have looked up the parties mentioned, and in every case have located and placed surveillance over them within twenty-four hours of receiving such notice, until the danger had passed.

Some of the cases of diphtheria might have been prevented had not the parties been careless. In one case the party who laid out the body of one who died with the disease went to her own home directly after, and slept in the same bed with her child; that child took the disease and died. A cousin of the child took the disease from her by sleeping with her when she was first taken sick. Before the physician's notice was received by the Board of Health of the first case, the patient was dead. Two members of the Board immediately went to the house of the deceased, and gave instructions to the parents of the child what to do in the way of disinfecting the house and clothes, and the method of washing the clothing and bedding. They were informed by the parents that no one had been in the house outside of the family, and so the Board were led to believe at that time that others had not been in danger. After learning the facts in the case, the Board issued orders to those families from which cases were reported, and

had them enforced; and the Board felt that, after the last case was reported well and the places had been disinfected, there would be no danger from these sources. During this time circulars were distributed by the Board throughout the town, giving instructions what to do in case of diphtheria. The schools in that district were ordered closed and the school buildings disinfected.

There is no question to come before the town at the annual meeting of so much importance as the question of sewerage. We have a vast number of privy vaults and sink drains which are a nuisance, and always will be until they are done away with forever, owing largely to the fact that the ground has become thoroughly saturated with their contents, as they are situated in a clay pan which will not allow the liquids to drain away.

Provincetown.

During the past year the Board of Health has done its best to prevent the spread of typhoid fever, which was so prevalent the year before, and to a certain extent has been successful. Early in the summer this disease again started in the same district as heretofore, but instead of nearly eighty cases, as in 1891, there were less than thirty. This to a great extent was due to enforcing the laws of cleanliness and care in the use of infected water. Two hundred and seventy-six outhouses, not including cesspools, were cleaned out by order of the Board of Health, over half of that number being in the infected district. Another year it is hoped that even better results may be realized, and we believe that the introduction of water will be a factor in augmenting the immunity from this and other diseases.

Quincy.

A case of small-pox was reported to the Board on June 24. The patient, a native of Sweden, had come to Quincy June 15, directly after her arrival in this country, and was taken ill on June 21. The case revealed itself as small-pox three days later, and during that interval eleven persons had been exposed to the contagion. The Board of Health lost no time in taking precautions against the extension of the disease. Ten of the persons who had already been exposed were removed to a building behind the almshouse, where they were maintained in effectual quarantine until July 12. The eleventh person was retained as nurse at the infected house, and the services of a competent and experienced nurse were also secured from Boston. The neighborhood of the house in which the patient lay ill was placed in strict quarantine, and all persons who had been exposed to contagion were vaccinated at intervals of two days until the operation was successful. After the recovery of the patient, the dwelling was thoroughly disinfected, most of the furniture, bedding, etc., being destroyed by burning. In spite of the extent to which the community had been exposed,

we are happy to say that no second case made its appearance, a result which, we are sure, will be considered more than sufficient compensation for the expense incurred by reason of our measures of protection.

In a preceding report we took occasion to point out the danger to health caused by the use of wells as a water supply. We wish to repeat this word of caution. In order to make evident the reasons for our belief, we wish to call your attention to the extensive prevalence of typhoid fever in the region bounded by West, Centre and Willard streets. An outbreak of this disease occurs yearly on West Street with perfect regularity. There is scarcely a house upon the south side of the street that has not been visited by it within the last three years, while some families have had three, four or even five cases of this malady. Some of these cases have of course proved fatal. Inasmuch as we are convinced that the disease is caused by use of the polluted water in the wells of this neighborhood, we recommend the early introduction of the Quincy water pipes into the territory in question.

Rockland.

Most of the cases of typhoid fever were confined to the eastern part of the town. The Board carefully looked over two large manufactories and some residences in that part of the town, though they could not satisfactorily locate the cause of so many cases. In several instances we learn the afflicted ones had used well water for drinking purposes, and those who did not use it escaped the infection. One or two of the worst cases reported occurred in the south part of the town, where their cause was fully established as resulting from using contaminated well water.

Heretofore the subject of ventilation has not received the attention which it demands, and it is a lamentable fact that to-day very few of our buildings, either public or private, are properly ventilated.

We have had several calls to investigate diseases of animals the past year, and we unhesitatingly say that if more care were taken in the ventilation of buildings where animals are kept there would be less disease among them.

It would seem to us the part of wisdom that all swill, whenever practicable, be burned, for it is much the safer way until we have become thickly settled enough to afford to have a garbage cart.

There is a growing feeling that no person should be allowed to keep swine in the thickly settled portions of the town.

Salem.

Cremation of garbage. — The possibility of the contractors being obliged at short notice to give up the taking of swill at any time, on account of an order from the town of Peabody, would place the Board in a very awkward position, and the city also. The present method is primitive, and decidedly behind the march of progress in this direction, and this Board strongly

recommend to their successors that steps be taken to carry out this most necessary improvement. Salem should be among the first, not the last, to have a first-rate crematory of modern dimensions.

Saugus.

During the year we have escaped the visitation of any serious epidemic. What will soon be required as the town progresses, to put us in a thorough sanitary condition, will be a general system of sewerage, which the introduction of a public water supply generally demands.

We would call the attention of all owners and occupants of premises to the great importance of perfect cleanliness in and about all dwellings; the cellars should be kept clean, dry and free from all decaying matter and well ventilated. Stagnant water should not be allowed to remain near your place of residence; no garbage or other refuse matter should be allowed to accumulate in your yards; nothing that produces obnoxious or injurious odors about the premises should be allowed, thereby polluting the air and producing a predisposing cause of diphtheria, scarlet-fever, sore throat, cholera infantum and other conditions of ill health. Impure air and water are the conditions which favor the spread of disease after it is once established. Much ill health can undoubtedly be prevented by careful attention to these suggestions.

Somerville.

Number of nuisances abated, 824; referred to Board of 1893, 381; complained of, 1,205; complaints (many covering more than one nuisance), 584; tenements ordered vacated, 5. Many nuisances have been abated on verbal notice from the agent, without any action of the Board, and of such no record has been made.

In the last week of August of the present year the attention of the Board was drawn to an unusual appearance of typhoid fever in Somerville. A brief investigation showed that there was danger of a serious epidemic, and, as the cause of the trouble was not apparent, the Board appealed for assistance in its inquiry to the State Board of Health. The latter responded promptly, and instituted a most careful and thorough investigation. Much time was necessarily occupied in tracing the cause of the disease, and the State Board has not yet prepared its final report. For a detailed account of this epidemic, see Professor Sedgwick's report to the State Board of Health, p. 726 of this volume.

Southbridge.

A general inspection and vaccination of school children was advised and executed early in the year.

During the year that portion of the town which seemed in greatest need has been provided with a sewer. It is deemed advisable by the Board that

the town take some action empowering the Health Board to regulate the connections with the sewer. Unless these connections are properly made and adequate trapping and ventilation provided, the sewers will be a source of great danger to occupants of houses connected.

Springfield.

The history of an unusual epidemic of typhoid fever, traceable to an infected milk supply in Springfield, will be found in this report, on page 715.

The house-to-house inspections have been increased, with good effect. The placarding of places where contagious diseases have occurred, and the caring for the premises by fumigation and disinfection, have received the attention demanded. We are free to say that the occupants of these places, as a rule, are much more disposed than in former years to follow the directions given them, and acquiesce in the placarding of their residences.

Public health and convenience, and a regard for public decency, demand that public urinals be erected in convenient localities.

Swampscott.

During the past year we have been put to considerable trouble by citizens not being prompt in notifying us of contagious diseases, as required by law.

The collecting of offal has been carried on the same as last year.

The manner in which the beaches have been kept has given general satisfaction, except the lower beach, where there are several cesspools and privies that should be removed.

Taunton.

The collection of ashes continued under the control of the Board until July 1, when it was placed in the hands of the street department, where no doubt the work is done at less cost to the city.

The collection of swill has been done, as formerly, by the overseers of the poor and by private individuals. The Board has had little complaint in regard to this manner of collections.

In view of the threatening epidemic of cholera, three special agents were appointed September 19 to inspect the more thickly settled parts of the city. In this way a large number of nuisances was found and abated which would otherwise never have been brought to the attention of the Board. During the time of this inspection, circulars calling attention to the necessity of cleansing all premises and buildings, and of using disinfectants in privies, etc., were printed and distributed to every family in the city.

The city has experienced an extensive epidemic of scarlet-fever in a mild form, the percentage of deaths being less than four. Every house known to contain a case of scarlet-fever has been posted with a card informing the public of the nature of the disease, and persons have been instructed in regard to quarantining the patient, and great pains have been taken to keep children out of school if they have been exposed to the disease. After the cessation of the disease the Board sees that the house is properly disinfected before removing the card or allowing the children to go to school.

During the year the building known as the pest-house, situated on land back of the almshouse, has been put in thorough repair and furnished with the bare necessities, so that in case of cholera or small-pox the patient could be carried there and cared for upon a few hours' notice. Of course this would not be a suitable or possible place to carry a child sick with scarlatina. There have been many times during the past year when a place suitable for such cases has been imperatively needed, and had we such a place many cases could be prevented.

Waltham.

Every possible effort was made by the Board to prevent the spread of scarlet-fever, and patients kept isolated as effectually as possible. Proper isolation of the cases was often impossible at the home of the patient, and in many such cases the efforts of the Board were rendered ineffectual by the lack of a suitable contagious hospital; and it is undoubtedly true that the disease could have been much restricted if the first few cases had been immediately removed to a hospital.

It was found by the Board that certain classes of people would not keep their children, who were convalescing from the disease, in the house, but allowed them to run about and mingle with other children. To prevent this, an officer was employed for a time to make daily visits to all such cases, to see if the rules of the Board were observed, and to warn parents not to allow their children to mingle with other children. This plan proved very effectual.

In last year's report the need of an infectious hospital was strongly emphasized, and during the first of this year the Board was asked by an aldermanic committee to furnish plans for one, and to confer with said committee in regard to a site for the same. Plans were accordingly furnished, which called for an administrative building with two wings, one for scarlet-fever and one for diphtheria, each to hold twenty-eight patients; also a small building to hold eight small-pox patients, to be situated at a reasonable distance from the others. It was thought by this Board that it would be enough to build a small-pox hospital and the other hospital, with the exception of one of the wings, leaving provision for its addition when needed in the future.

The Board is doing its best to prevent the pollution of the Charles River along its course through the city; and it is hoped that the city will acquire such portion of the banks of the stream as can be readily obtained, for park purposes. This Board, through delegates, has conferred with the boards of health of Newton, Watertown, Weston, Needham, Milford, Somerville, Cambridge and Boston, in regard to the prevention of pollution of the Charles in its course through the cities and towns named, and several meetings have been held for this purpose, resulting in the drafting of a bill to be presented to the General Court at its present session, for the purification of the Charles River and the improvement of its banks, in the interest of public health.

Ware.

The water supply and the sewerage system of the town offer great advantages in promoting health, and are very widely made use of.

As the last report of the State Board of Health gives this town a prominent position in respect to fatality from typhoid fever, compared with the population, during a period of twenty years, namely, from 1871 to 1890, we made inspection of the records in the town clerk's office, and find that, of the one hundred and twenty-eight cases of persons buried here who died of typhoid fever during that period, only sixty-two, or less than one-half, of these belonged to our town; the others were simply brought here for burial, mostly from adjoining places, which at that time largely used St. William's cemetery or other burial grounds here.

Instances are frequent where clothing and furniture which have not been disinfected by sufficient exposure to air or other methods have conveyed scarlet-fever after a year's keeping or more. The method of oiling the patient and frequent bathing, with disinfection of the materials used in the bath, and the isolation of the individual from the others of the family, are valuable means for limiting the spread of this disease.

Vaccination has been attended to during the year in the case of all children attending the public schools who have never been thus protected. A large number was found who had neglected this matter, and, as it was deemed necessary to secure thoroughness and promptness, a considerable number was vaccinated at public expense.

Watertown.

In connection with the new improved sewerage of the town, the Board, in accordance with the provisions of the board of selectmen, has made a thorough inspection of the plumbing and sanitary condition of every building seeking admission into the public sewer. A large proportion of these buildings has been found to be in an unsanitary condition. From the experience of the Board thus far they are strongly persuaded that it would greatly conduce toward preserving the public health of the town if this

house-to-house inspection thus begun could be carried on throughout the entire town.

In view of the urgent need of a more sanitary method of disposing of the swill and garbage collected from the town than the one hitherto employed of feeding it to the swine upon the town farm, thereby maintaining in the piggery a greater public nuisance than would be tolerated upon any private premises, it is advisable that the town begin to seriously consider the expediency of building for itself a crematory, wherein all such polluting refuse may be safely consumed. Burning, as a method of disposal for all such refuse, is now very generally commended by sanitary experts, and its introduction is being contemplated by several of our neighboring municipalities.

It would be a very great relief to the town if the stock yards could be induced to remove from within the town borders. They are very objectionable, not only by reason of the animals themselves, but also by reason of their undesirable attendance.

Williamstown.

The Board of Health would again call the attention of the town to the fact that no building has been provided for patients with small-pox or other contagious diseases which require complete quarantine, although a sum was voted for that purpose. It is next to impossible in private houses to carry out perfect sanitary precautions. And, although it has been our good fortune to escape without a widespread dissemination of scarlet-fever and diphtheria, the germs of which diseases are present in our midst, it is not attributable to our sanitary arrangements. We recommend that a sufficient sum be appropriated for the erection at the town farm or other locality of a suitable building to be used in case of necessity, solely for contagious diseases.

Examination of animals for tuberculosis. On Nov. 22, 1892, I examined the first herd, and completed examinations on Jan. 28, 1893. During that time I examined 1,362 head, and found two animals affected with tuberculosis. I ordered them destroyed, and immediately notified the State Board, and three days later, in company with Dr. O'Connell (State veterinarian), I again visited the herd and found that the animals had been destroyed.

Winchester.

At the time of writing this report a striking example of the spread of contagious disease through a school district is afforded by the epidemic of measles prevailing among the Wyman School pupils, twenty-five of whom are now reported as affected through the careless attendance of some child.

We cannot too strongly recommend the building of a thorough system of sewers when the Metropolitan sewer is so far completed as to insure an outlet to our system. It is expected that the Metropolitan sewer will be

complete from its outlet to Winchester in 1894, and by another year it is hoped that Winchester will build its local system.

The unusual prevalence of typhoid fever during the past year in some of our neighboring towns and cities has arrested our attention, but our town has fortunately escaped the malady. In consequence of the intimate connection of this disease with a sewage-polluted water supply, this Board has felt that every precaution should be taken by our water board to preserve the purity of our water supply. The only safeguard for us is to "keep clean," — see that our water, air and food are not polluted, and we have the best safeguards obtainable.

We feel that a town of the importance of Winchester should employ a "health officer" who could also be a "plumbing inspector," as well as attached to the police or fire department. The officer could properly and officially attend to the many duties of the Board, such as posting the cards at the houses, investigating nuisances, inspecting milk, provisions, meat, water and ice supplies, attending to the fumigation of all places where infection exists, and in many other ways be of great service and value.

Winthrop.

The question how to dispose of such sewerage as was not provided for either by public or private sewers was one not easily settled; but, after considerable time and discussion being given to the matter, it was finally thought that the sewer tank located at Short Beach might be a proper place to dispose of the vault and cesspool product. Before making any use of this receptacle, the Board consulted the engineer who had charge of the construction of our beach sewer, and Mr. Whitman informed the Board that it would be a proper place to dispose of the material referred to, and that it could in no way injure the mechanism of the tank or its valve, or in any way retard the successful operation of the same; and now that the season's work is ended, we are able to say that the tank has taken care of such product as we have placed there, and in an entirely satisfactory manner. Certainly this plan ought to be much more satisfactory to the general public than the way of disposing of the vault and cesspool matter of previous years.

Since the close of the summer season the Board has been busily at work causing every house located on the line of the public sewer to be connected with the same, and the work was completed, with one or two exceptions where parties could not enter without crossing other land. The number of houses recently caused to be connected with the sewer is one hundred and one.

Woburn.

The diseases which the Board of Health of the city of Woburn considers dangerous to the public health within the meaning of the Public Statutes, chapter 80, sections 78 and 79, and which attending physicians and house-

holders must report to the Board of Health, are: cholera, yellow fever, small-pox, varioloid, diphtheria, membranous croup, scarlet-fever, typhus fever, measles, typhoid fever and cerebro-spinal meningitis.

Worcester.

Scarlet-fever has prevailed more extensively during the past year than in any other year since 1884, when the record of contagious diseases was begun. The epidemic has been exceedingly mild; out of four hundred and forty-nine cases, only sixteen deaths have occurred. Since the summer vacation the number of cases has steadily decreased, and with the beginning of 1893 the disease is but slightly prevalent.

During the year ninety-two cases of typhoid fever were reported, resulting in nineteen deaths. A large proportion of these cases was brought in from other towns. A thorough inspection of the house is made in every case, and a record is also made of the water and milk supply.

The epidemic of diphtheria and scarlet-fever to which we have been subjected during the past year has impressed upon us more forcibly, if possible, the urgent need of a hospital for contagious diseases. The city is growing fast, and the number of people who are living in boarding-houses and hotels is increasing. Then, too, there are the poor who are living in small and crowded tenements with large families, where it is an utter impossibility to properly isolate the patient, and give to him that care absolutely necessary to his recovery. There is another side to this question, also. When diphtheria or scarlet-fever breaks out in one of these poor families, the bread-winner is forced to leave his work, the children are obliged to remain out of school; no one will harbor or even visit them, and all are forced to live in the crowded tenement in the midst of contagion. Their situation is indeed pitiable, poverty adding to their miseries. Is it any wonder, then, that in many instances two, three and even four of the children are swept away by this terrible scourge before its work is ended? The wonder rather is that there are not more of these fatal instances to record. A suitable hospital for this purpose, where patients who live under these conditions could be promptly sent, would save many lives and much misery. Surely, then, the possession of such an institution is demanded by humanity and Christianity, as well as by the selfish motive of self-preservation.

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